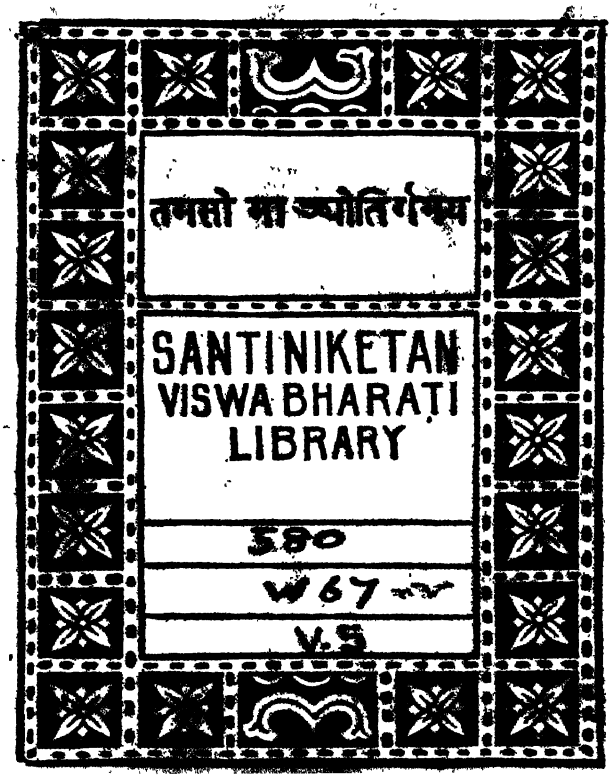

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TREES

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TREES

A HANDBOOK OF FOREST-BOTANY FOR THE WOODLANDS AND THE LABORATORY

BY THE LATE

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VOLUME V. FORM AND HABIT

WITH AN APPENDIX ON SEEDLINGS

WITH ILLUSTRATIONS

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EDITOR'S PREFACE

IN seeing the present volume through the press I have reduced changes from the original to a minimum. Of the trivial verbal alterations, inevitable in revision, no special indication is supplied in the Text, but I have found it necessary to make a few alterations and additions that are denoted by enclosure within square brackets.

In regard to the subject matter of this volume it may be remarked that Chapter VII., should not be regarded as giving a strictly defined histological account of Bark. The Appendix, dealing with Seedlings, though evidently not in the final state to which the Author intended to bring it, is yet sufficiently complete to be of great use to students, and more especially so thanks to the excellent drawings made by Miss E. Dale from actual seedlings.

A number of the illustrations (unsigned) are from drawings made by the Author. Others obtained from various botanical works are acknowledged as in the preceding volumes. Those marked "Irv" are from photographs made by Mr Henry Irving; of these, eight have been previously published in my book *Trees and their Life Histories*. While the illustrations initialled "E. D." are from drawings by Miss E. Dale, who has been good enough to calculate the respective scales of magnification or reduction.

As in the case of preceding volumes, Mrs Marshall Ward is responsible for the preparation of the Index.

PERCY GROOM.

IMPERIAL COLLEGE,
SOUTH KENSINGTON.
March, 1909.

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PART I.

GENERAL.

CHAPTER I.

HABIT.

Distinctions between trees and shrubs—Trunk and crown—Transitions between trees and shrubs—Dwarfed Scots Pines described by Darwin—Bush—Different forms assumed by woody plants—Prevalent form of European trees—Distinctions among these—drooping, fastigiate, spreading and terraced, and pyramidal forms—Causes of these distinctions—Lombardy Poplar and Spruce—Weeping Willow and Cedar of Lebanon—Cypress, Ash, and Larch—Horse-chestnut, Beech, and Birch—Shrubs and bushes—Woody creeping and climbing plants—Coppiced and pollard trees—"Round-headed" trees—Angle at which branches are given off—Terms—trunk, bole, limbs, branches, twigs, shoots, and spray.

NONE of my readers would find any difficulty in pointing to examples of trees and of shrubs, though any one of them could easily fix the attention on individual woody plants not obviously included under either head. On examining the matter it is clear that the typical and unmistakable tree has a single principal stem, known to foresters as a *bole* or *trunk* where large timber trees are concerned, and that this ramifies above into a *crown* or head of branches; whereas the universally accepted definition of a typical shrub turns on the fact that no one stem can be claimed as the principal bearer of the

crown, because several or even many spring direct from the soil, and assume equal importance in the formation of the leafy crown.

Thus far matters are simple enough, but while a lofty tree such as a well-grown Oak, Beech, or Elm, or an old Scots Pine, exhibits an unmistakable trunk 20 to 60 or more feet in height, plenty of examples may be found where the branches of the crown arise so low down that even the very thick bole is only a few feet, or even only a foot or two high in the clear, and the form approaches very nearly to that of the shrub.

The position is complicated by the existence of very many trees in which no definite crown is developed until very late in life, as in numerous species of Pines and Firs which put out branches at all heights from base to apex and maintain them for a large number of years; and even tall Elms, 80 to 100 years old, may be thus clothed from top to toe with foliage-bearing shoots, and the crown can no longer be regarded as a head but must be looked upon as distributed over the whole trunk, the superior length and massiveness of which alone fit the accepted definition of a tree.

Further complication arises from the fact that natural or artificial interference with the normal development of the tree often imposes upon it an approach to the form of a shrub. Examples in abundance are provided in situations where extremes of climate, or the recurrent breaking weight of snow and ice, the pressure of wind, &c., bring about repeated dwarfing or fracture of the main stem, or of any strong branch which attempts to rise to the proportions of such: for instance, the dwarf shrubby Birches of sub-arctic or alpine regions, or the stunted Oaks, Hawthorns, &c., near sea-coasts, and so forth. Illustrations of the incidence of artificial conditions are afforded by the



Fig. 1. *Picea excelsa*, Spruce (B).

Hazels of any copse, or the Willows of any osier-bed where, the main stems having been cut down close to the ground, numerous basal branches of approximately equal strength arise, and the whole assumes the shrubby form of Coppice. Similarly with the close-cut hedges of Hornbeam, Beech, Yew, &c., met with in many parts of the country. A striking example of the effects of continued pruning by animals is that of the Scots Firs described by Darwin[1]: I quote the case *in extenso*, since it is very instructive on several points. "In Staffordshire, on the estate of a relation, where I had ample means of investigation, there was a large and extremely barren heath, which had never been touched by the hand of man; but several hundred acres of exactly the same nature had been enclosed 25 years previously and planted with Scotch fir. The change in the native vegetation of the planted part of the heath was most remarkable, more than is generally seen in passing from one quite different soil to another: not only the proportional numbers of the heath-plants were wholly changed, but twelve species of plants (not counting grasses and carices) flourished in the plantations, which could not be found on the heath. The effect on the insects must have been still greater, for six insectivorous birds were very common in the plantations, which were not to be seen on the heath; and the heath was frequented by two or three insectivorous birds. Here we see how potent has been the effect of the introduction of a single tree, nothing whatever else having been done, with the exception of the land having been enclosed, so that cattle could not enter. But how important an element enclosure is, I plainly saw near Farnham, in Surrey. Here there are extensive heaths, with a few clumps of old Scotch firs on the distant hill-tops: within the last ten years large spaces have been enclosed,

[1] *Origin of Species*, 6th ed. 1885, p. 55.

and self-sown firs are now springing up in multitudes, so close together that all cannot live. When I ascertained that these young trees had not been sown or planted, I was so much surprised at their numbers that I went to several points of view, whence I could examine hundreds of acres of the unenclosed heath, and literally I could not see a single Scotch fir, except the old planted clumps. But on looking closely between the stems of the heath, I found a multitude of seedlings and little trees which had been perpetually browsed down by the cattle. In one square yard, at a point some hundred yards distant from one of the old clumps, I counted 32 little trees; and one of them, with 26 rings of growth, had, during many years tried to raise its head above the stems of the heath, and had failed. No wonder that, as soon as the land was enclosed, it became thickly clothed with vigorously growing young firs. Yet the heath was so extremely barren and so extensive that no one would ever have imagined that cattle would have so closely and effectually searched it for food. Here we see that cattle absolutely determine the existence of the Scotch fir."

I have myself gathered a Larch on the ice-locked moraine of the Aletsch Glacier, which, although only a scrubby little bush of a few inches high, showed 13 annual rings in its stout little stem, and had evidently been kept down to this stunted condition by the pruning action of dry, cutting winds combined with periodic droughts and long resting periods: its root-system was long and large out of all proportion to the stunted growth of the shoot-system.

It will be evident from the foregoing that any attempt at rigid classification of the forms of woody plants into trees and shrubs must result, in individual cases, in failure. And nevertheless such terms as tree, shrub, and bush—a

bush is a small tufted shrub—are not totally devoid of practical significance: we may still insist on the fact that *many plants normally direct a maximum of growth-energy into* one principal stem from the first and maintain this for many years, the result being a tree with a thick, woody trunk or bole: whether this eventually bears all its branches above only, as in old Oaks and Pines, or bears them along its course as in the Common Elm and Firs, whether the trunk is traceable to the top of the whole tree as in most Conifers, or soon breaks up into dividing or forking branches as in Beeches, Maples, &c., whether the whole is large and tall as in normal Larches, Ash, &c., or small and low as in Hawthorn, Box, &c., are incidents partly dependent on the specific nature of the tree, and beyond our explanation at present, but partly due to the action of the environment and often definitely referable to such.

And similarly with shrubs and bushes. There are some, such as certain Willows, Brambles, &c., which probably never assume the tree-form, in the sense of elevating a single trunk bearing a crown; others, as many climbing plants—e.g. Clematis, Ivy, &c.—which have special forms quite distinct in their kind; others again which though usually shrubs can be readily forced into the tree-form by pruning and cultivation—e.g. *Prunus spinosa*, Barberry, &c.; and yet others which will normally develope into small or even fairly large trees, but are usually met with as shrubs—e.g. Hawthorn, Holly, Yew, Hazel, &c.

Possibly any shrub could be compelled to assume the tree-form, or an approach to it, by suitable cultural treatment, and it has already been shown that many trees are habitually forced into the shrubby habit by pruning, coppicing, &c. Of course we are not here concerned with the extreme cases of trees which become bushy at the

limits of perpetual snow in high latitudes or on lofty Alpine ranges.

With this introduction I pass to the subject of the general habit of trees and shrubs.

If we cast a glimpse at the various kinds of trees and other woody plants growing in various parts of the world, a task of no great difficulty in these days of photography, it is obvious that a number of types may be easily selected based on their sizes, shapes, and modes of branching and of carrying their foliage.

Conspicuous examples are at once furnished by the Tree-ferns, Palms, Bamboos, and species of *Pandanus*, *Musa*, *Strelitzia*, and *Ravenala* of the tropics; the *Papyrus* of the Nile; the Yuccas, Aloës, and Agaves of Mexico and S. Africa; the *Dracæna* of Teneriffe and the curious Australian *Xanthorrhœa*; the Cactaceæ of tropical America, and the Stapelias and Euphorbias of S. Africa; the Casuarinas of Australasia, and the Ephedras of the Orient and elsewhere; the tropical Banyans and Mangroves; the sub-arctic and alpine Heaths, and their S. African and Australian representatives, to say nothing of the curious *Welwitschia* of Damaraland, and numerous lianas and stranglers and parasitic plants of various parts of the globe.

These are striking examples which have been noted over and over again by travellers, and many of them were selected as types of vegetation by Humboldt and the earlier pioneers of Geographical Distribution.

But even our European trees and shrubs afford us illustrations of the theme, as is evident if we compare and contrast such plants as the creeping pine (*Pinus Pumilio*) of the Caucasus and Pyrenees, with the erect pyramidal Spruce (*Picea excelsa*) of Norway (Fig. 1), the spreading and terraced Cedar of Lebanon (Fig. 6), or the umbrella-



Fig. 2. *Pinus Pinea*, Stone Pine (F).



Fig. 3. *Cupressus sempervirens*, Roman Cypress (F).

like Stone Pine of Italy (Fig. 2); or the erect and almost cylindrical fastigiate Lombardy Poplar (Fig. 4) and the Mediterranean Cypress (Fig. 3) with the broad spreading Oak, and, even more striking, the Weeping Willow (Fig. 5). Further instances are easily found among our climbing plants, such as the scrambling Blackberries, the root-climbing Ivy, the twining Hop and Honeysuckle, leaf-climbers such as Clematis and tendril-climbers such as the Vine.

At first sight, however, it may appear that if we confine our attention to British trees and shrubs their similarity or even monotony of habit is fatal to any attempt at classifying them by their general characters of growth. This is to some extent true. The prevalent form of our ordinary trees so generally approaches a single type—e.g. that of a trunk bearing a more or less rounded head of foliage, as in any well-grown Lime, Oak, Beech, &c.—that some observation is needed to detect sufficient differences by which to separate them at a distance, and without reference to details. A little reflection, however, suggests that distinctions must exist, otherwise artists and foresters would not recognise trees in the way they do; and further consideration of the matter convinces us that if we properly examine the general effect of the form and colour of trees, much can be done in the way of familiarising ourselves with them in the landscape as we travel past—say in a carriage, or even in a railway train; and, as our experience grows, acute observation of such additional points as relative size, depth of shade, heaviness or lightness of foliage, rigidity or otherwise of branching, and the angles of divergence, flexuousness, and so forth, of the twigs, persistence of leaves, together with peculiarities of growth and situation, lead to the summation of a number of characters which lose vagueness in proportion

to our accuracy of perception and appreciation of the differences they express. For example, most people readily familiarise themselves with the strikingly distinct types which I may enumerate as the *drooping* habit of the Weeping Willow, the *fastigiate* one of the Lombardy Poplar, the *spreading* and *terraced* form of the Cedar of Lebanon, and the tapering *pyramidal* form of the Spruce and other Firs.

If we examine the broad essentials which are concerned in bringing about these very distinct types, they are found to be somewhat as follows.

In the Lombardy Poplar (Fig. 4) and the Spruce (Fig. 1) the principal branches are subordinate to the main stem, but in quite different ways. In the former they rise at a very acute angle and ascend almost parallel with it, each again giving off similarly nearly vertical branches. In the Spruce, however, the principal branches come off approximately at right angles, and in whorls or nearly so, and then sweep downwards and outwards in flowing curves, bear their subsidiary branches right and left and also sweeping downwards and outwards at wide angles; and, since there is very regular gradation of growth from the older and larger lowermost to the younger and shorter topmost branches, the tapering habit is long maintained. Further differences are due to the broad leaves, relatively few in number and poised on long petioles in the Lombardy Poplar, as contrasted with the very numerous crowded and sessile narrow leaves of the Spruce that give the plumose appearance so characteristic of the Firs. Moreover the foliage of the Poplar is deciduous—i.e. is all shed in the autumn, whereas that of the Spruce remains on for several years, whence the tree is termed evergreen.

Now let us turn to the other two types selected. The

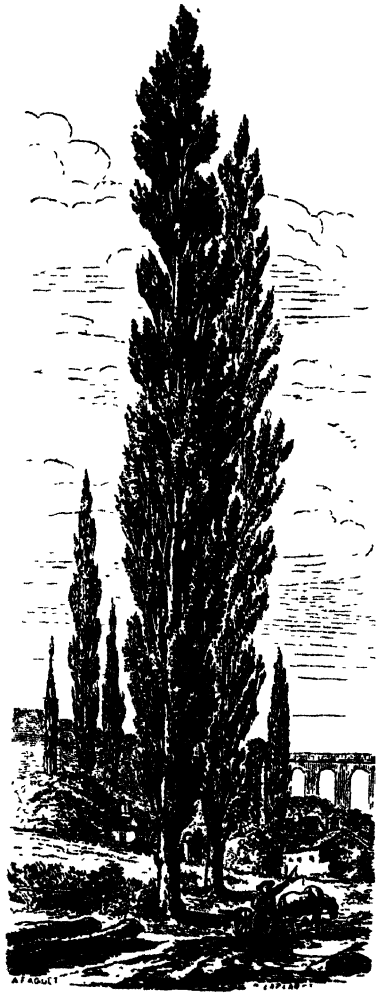


Fig. 4. *Populus nigra* v. *pyramidalis*, Lombardy Poplar (F).



Fig. 5. *Salix babylonica*, Weeping Willow (F).

Weeping Willow (Fig. 5) obviously differs from the Cedar (Fig. 6) in the flexuous curves of its branches and especially the pendulous twigs, which are in marked contrast with the rigid prop-like principal branches of the Cedar bearing their wide-spreading subsidiary branches extended right and left, and often in or near the horizontal plane. Both trees differ from our first two types in the prominence of their lateral branches, making the stem a far less conspicuous object in the architecture. But one, the Willow, is deciduous and bears foliage of a peculiarly light hue, while the other, the Cedar, is evergreen and carries tufts of stiff narrow leaves so numerous and so dark that the tree appears almost black in certain lights.

If all our trees exhibited broad characteristics as marked as these, no one could experience much difficulty in distinguishing them at a distance, and, although this is by no means the case, it is easy to compare and contrast many others with the types sketched.

The merest tyro would at once refer the tall Cypress (Fig. 3) to the fastigiate type, and the pendulous Ash to that of the Weeping Willow, while the Larch (Fig. 67) would remind him in its general architecture of the pyramidal Fir, and in its thin foliage of pendulous twigs of the Birch, but the majority of our trees present features of conformation far more subtle than these. For instance, while it is not difficult to trace resemblances between the terraced crown of the Cedar and similar terracing—but developed in very different ways and degrees—in the masses of foliage of the Horse-chestnut, Beech, &c., or between the graceful drooping of the pendulous branches of the Birch and the weeping habit of the Willow; these resemblances are combined with differences not always easy to describe; and when we try to characterise the majority of our trees, such old-fashioned expressions as

Fig. 6. *Cedrus Libani*, Cedar of Lebanon (F).

"round-headed," "spreading," "erect," and so forth, vague as they are, are difficult to escape.

Similar problems beset us on examining the habit of shrubs and bushes. It is very easy to select certain well-marked types, such as the creeping or trailing Willows, e.g. *Salix repens*, and the various climbing shrubs, be they Twiners like the Honeysuckle, Tendril-climbers such as the Vine, Scramblers like the Blackberry, or Root-climbers like the Ivy; yet the vast majority of them are more or less erect, "round-headed" shrubs, only differing from trees in having no single and distinct stem, but bearing their foliage shoots on a varying number of branches that rise direct from the ground or from the base of one or more principal stems.

Moreover, apart from size and shape which offer us no constant distinction between tree and shrub, the difficulty arises that coppiced trees—i.e. trees which have been cut down close to the ground and allowed to throw up several branches from the stool—are in the condition of shrubs, and remain so until some one of the branches takes the lead and forms a new stem. The peculiar forms presented by coppiced trees, moreover, are entirely artificial, as is also that much more conspicuous form known as the pollard. A pollard Oak or Willow in fact only differs from a coppiced Oak or osier Willow in the height at which the lopping of the stems and branches is performed; in the former at some feet above the surface of the soil, in the latter close to the ground.

It will be the subject of a later chapter to investigate the part played by the branches in building up the form of the crown, but meanwhile attention may be directed to some broad features in the large class of "round-headed" trees. Any observant person must have noticed that one marked difference between the crown of an Oak, Plane, or

Walnut, and that of a Norway Maple, a Beech or Lime, or an Ash, consists in the angle at which the principal branches come off from the trunk; or, as it is often expressed, in the way the trunk breaks into the crown in each case. In the former the heavy branches (limbs) come off approximately at right angles and zigzag principally in the horizontal plane, whereas in the latter they ascend at more or less acute angles with the vertical and break into twigs or spray at their upper ends. It is true the weight of the foliage may bend down these branches into more or less graceful curved forms, and so cause the crown of a large tree to spread widely above (e.g. Lime, Wych Elm, &c.), but the principal point of difference is the prevalence of acutely forked branches where the trunk passes into the crown in the Beech and Ash, as contrasted with the wide open angles in the case of Oak and Walnut. Every boy who has climbed trees knows the difference of knee-hold afforded by the two types.

At this point in the discussion it may be worth while to adopt certain terms, avowedly conventional, which will aid us in our conceptions and descriptions to follow. Accepting the terms bole[1] or trunk for the large stems of our timber trees, we may also go further and adopt the somewhat popular term "limb" for those principal branches, of timber size, which leave the trunk at wider or narrower angles to carry the solid weight of the crown. This leaves us free to restrict the word "branch" to all the smaller off-shoots from the limbs, until we reach the periphery of the crown, where the daughter-branches, bearing the leaves and buds, are so thin that they are usually termed "branchlets," "twigs," or "shoots." But it will be useful

[1] [It is advisable to restrict the term "bole" to the lower part of the trunk, where this is devoid of boughs. That is to say the "bole" is below the crown, but the trunk extends up into the crown.]

to restrict the term twig to those only which have already lost their green colour and leaves, and have ceased to elongate and have become woody, or, in evergreen plants, to the parts which have ceased to elongate. If this is accepted we may restrict the term "shoot" to the green and still growing shoots of the present season. To be more precise, a shoot is the still green shoot of the current year, on which the epidermis is still intact and from which the present season's leaves have not yet fallen; a twig is what was the shoot of last year or of the year before, on which the cork or periderm is usually already developed—whence the change from clear greens to other hues—and in which sufficient wood is already formed to give it a tough, brittle character as opposed to the soft, herbaceous texture of the green shoot. It is not worth while to attempt closer definition, or to apply the term twig further back than the second or third year; but it is necessary to point out that if the above is accepted, a large deciduous tree in its winter state has no shoots: the shoots of the season have now become twigs and bear winter buds, each of which may grow out into a shoot next spring. In its summer condition, such a tree consists of trunk, limbs, branches, twigs, and shoots, the latter bearing the leaves of the season.

Another term likely to be of use in the description of trees may be borrowed from the artists—i.e. the word "spray." If we define spray to mean the assemblage of twigs and shoots borne by a branch, it attains sufficient exactness for our purpose. Nor is this spoilt for practical purposes by the qualification that, in winter, the spray of deciduous trees will consist only of a series of twigs; where it is necessary to enter into more detail we may speak of leafy spray or spray of twigs as the case requires.

CHAPTER II.

STEMS AND BRANCHES.

Stem—Length of internodes—Duration—Branching—Herbaceous and woody—Types of stem—Culm—Stock—Trunk—Bole—Stool—Surface of stem—Shapes of herbaceous stems and twigs — Branches — Arrangement — Ordinary branches and dwarf-shoots—Death of terminal buds—Terminal flowers—Positions of flowers—Changes in symmetry of branching.

OUR study of the Bud has shown that the stem is merely part of the shoot-system, and in its ordinary typical form it is that part which acts as a support to the leaves which it developes at its apex.

It is for so many purposes convenient to consider the stem apart from the structures which it bears, notwithstanding that botanists habitually speak of it as if it were an integral part of the plant. Strictly speaking the stem cannot be thoroughly treated scientifically apart from its lateral outgrowths—not necessarily leaves, nor even leaf-structures—but we may concentrate our attention on some peculiarities of the stems of ordinary plants to facilitate the understanding of other matters.

In the embryo of germinating seeds, or in resting bulbs or other buds, the stem or primary axis of the shoot is always short, and in many cases it remains very short throughout the life of the plant. In the Daisy, Dandelion,

Male Fern, Dock, London-pride, Plantain, &c., for instance, the stem is merely the short portion bearing the crowded rosettes of leaves and scarcely projecting above the soil. In sharp contrast to these are the tall stems of very many common plants such as the Nettle, Sunflower, Willow, Ash, Bamboo, Palm, Tree-fern, &c., and comparison shows that the principal difference between these two sets of stems depends on the elongation of those parts of the axis situated between the leaves, and devoid of leaves: the internodes, in other words, are very short in the first case and long in the second, and many peculiarities of stems are traceable to this difference in the degree of elongation of the internodes as the shoot developes.

Other differences are observed in the duration of the stem. While that of a Banana, Palm, Pine, or Oak is perennial, living for many years, those of many plants are annual or biennial (Mustard, &c.).

But it is evident that even the examples mentioned differ in other points; thus the Banana, Palm, Tree-fern, and many others do not usually branch, whereas most ordinary shrubs and trees do so abundantly; again, while the Nettle, Daisy, and Sunflower stems are herbaceous, those of the trees referred to are woody after the first year.

While it is useful and necessary to make these distinctions, however, the student should nevertheless understand that the differences referred to are relative. This is obvious as regards short and long internodes, but it is also true of the duration of stems, for many plants, in one country or under certain methods of treatment, throw up annual stems, which under other conditions become biennial, or even perennial.

In the case of herbaceous, as contrasted with woody stems, too, it must be understood that the soft stems of

the former are not devoid of wood altogether, but that in them the wood does not develope so much as to preponderate over the softer tissues of the structure as is the case with the latter.

Even branching is not independent of conditions. Most Palms, for examples, although they live for many years, do not branch as usually understood, but it is by no means uncommon to find individuals which have taken to doing so, and many plants which do not usually branch can be compelled to do so by changes of conditions, as exemplified for instance by the nipping off of the terminal buds of strong shoots, pruning, or injuries of other kinds.

For purposes of description different names are given to stems of various kinds or their parts, by botanists, foresters, and agriculturists. Thus, the hollow stems of Grasses are often called *Culms*; short stems bearing rosettes of leaves close to the ground are called *Stocks*—e.g. Plantain, many Ferns, &c. The stout woody stem of ordinary trees is called a *trunk*, or [the part below the crown of branches is, by foresters, termed] a *bole*: the lower part of the stem of a felled tree is termed the *stool*.

The stems of herbaceous plants present numerous characters according as their surface is smooth, or variously covered with hairs and other outgrowths, well exemplified by contrasting the glabrous stem of many Willows with the softly hairy one (pilose) of others, or the hispid stem of the Borage. Prickles (Bramble), wings (Comfrey), ridges and grooves (Sorrel) are also common on stems.

Furthermore, the shapes of stems of herbaceous plants demand attention, and this in two ways. In the first place the general shape of the whole stem—thin and long, discoid, conical, globose, &c.—and, in the second, the shape in transverse section, e.g. square in Labiate

plants, circular, or triangular. Such stems may also be hollow, or solid, and all these characters may differ for the nodes and internodes respectively—e.g. the solid nodes of Grasses as contrasted with their cylindrical hollow internodes; the tumid, viscid, hairy nodes of certain Caryophyllaceæ, as contrasted with their smooth internodes, and so on.

In the case of trees, descriptive botany takes note of facts similar to the above so far as the young twigs of the current year are concerned, because these are practically herbaceous stems, but the older parts, and especially the trunk, have in the course of years obtained other coverings than those found on herbaceous parts, and the peculiarities of the periderm and bark have to be described. (See Bark[1].)

The above remarks apply to the ordinary stems, accepted as such by any observer. Before passing to the consideration of the various kinds of stem which depart more or less from the type, it will be useful to pay some regard to branches of various kinds, also as observed in ordinary plants.

In all the usual cases, as in our common trees and shrubs, Ash, Elm, Lilac, &c., it is obvious that the ordinary leafy branches (foliage branches) simply repeat the peculiarities of the principal stem from which they are outgrowths. We shall see later that there are certain generalisations to be made as regards branching, but for the moment the point is that the ordinary branch essentially repeats the structure of the stem: like the latter it ends in a bud, and has its own lateral outgrowths—leaves, other branches, &c.—and presents similar characters of surface, section, and so on.

[1] Vol. I. pp. 94—99.

It needs little observation to convince ourselves that these branches arise from buds closely associated in position with the leaves on the stems bearing them, and the length of the branch depends on exactly the same elongation of the internodes as in the cases considered above. In most cases these buds, and therefore the branches into which they elongate, are in the axils of the leaves, a fact which at once connects itself with the different kinds of branching we are familiar with. Thus, in the Rose, Elm, Lime, and Birch the branches are alternate, whereas in the Lilac, Maple, and Horse-chestnut they are opposite; while in the Oleander they are in whorls of three, in some Euphorbias whorls of five occur, and in Equisetum the numbers may run much higher.

On going further into this matter of branching, even only so far as concerns the ordinary cases, however, we soon find that several other points come into consideration beyond the mere arrangement of the branches on the axis which bears them, and exert profound effects on the appearance of the shoot-system as a whole.

If we examine a Pine or a Fir, or even an ordinary fruit-tree or Sloe, it becomes evident that branches of different kinds are developed on one and the same shoot-axis. Some of these exactly repeat the behaviour of the principal axis, bearing other branches and leaves as does the axis whence they spring: these branches with unlimited growth are the ordinary ones implied in general references to the subject. But we also find shorter branches which soon come to an end: these dwarf-shoots or spurs bear only two leaves, or three, or five in the Pines, besides a few minute scales, and are so short as to be like mere tufts, and do not themselves branch again; in the Sloe, &c., they are also short, owing to the non-extension of the internodes, and again their leaves give the impression of

being in tufts. Still closer consideration shows that dwarf-shoots and ordinary branches of unlimited growth are not so sharply marked off from one another, but are mutually convertible one into the other.

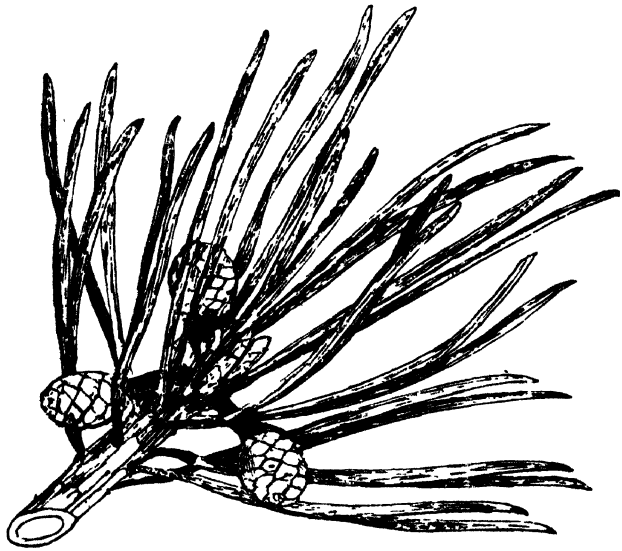


Fig. 7. Scots Pine, *Pinus sylvestris* (D).

Thus, in the Cedar and Larch, the tufts of leaves which characterise these plants are borne on dwarf-shoots, but it very commonly happens in wet summers that the internodes lengthen, especially in the Larch, and we get long whip-like twigs with the leaves separated by considerable distances. On the other hand, observation of the opening buds of the Horse-chestnut, Pine, Maple, Currant, &c., in any spring show that even the long branches begin as dwarf-shoots, and their lowermost

internodes never elongate much. Under certain circumstances, indeed, more of the internodes lengthen, and then



Fig. 8. Larch, *Larix europæa* (Wi).

we have what is normally a long branch with unlimited growth becoming stunted to a dwarf-shoot.

Dwarf-shoots occur normally in *Betula*, *Populus*, *Pyrus*, *Cratægus*, *Prunus*, *Rhamnus*, &c.

Another phenomenon, equally effective in modifying the aspect of the branched shoot-system, is the arrestation of branches by the death of the bud at the end.

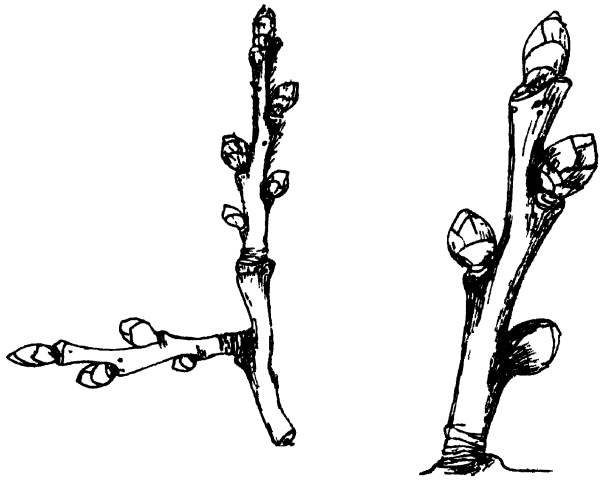


Fig. 9. Wych Elm, *Ulmus montana*. Twig to the right enlarged (D).

Every gardener knows that it is possible to produce abundant branching in some plants by artificially destroying the terminal bud, and explains it by assuming that the lateral buds, from which the flow of food-materials was diverted in great part by the demands of this strong bud, are now better supplied. Of course accidental destructions of buds go on in Nature and produce similar effects, e.g. by frost as occurs almost annually in the Elder. But apart from this many plants habitually have the ter-

minal buds on every branch die each year. The branches of the Elm, for instance, always lose the terminal bud as winter comes on in this country, and the apparent continuation in length of the branch next spring is due to the growth of the internodes of the next lowest lateral



Fig. 10. Blackthorn, *Prunus spinosa*. 1, flowering shoot; 2, fruiting branch; 3, flower in vertical section, enlarged; 4, fruit in section (Wo).

bud close to the tip (Fig. 9): similarly with the Lime, Birch, Chestnut, Hazel, Mulberry, where the remains of the dead terminal bud can be detected as a minute scar by the side (opposite the leaf or its scar) of the axillary one which at first sight appears to be the terminal one. In

some cases a distinct piece of dead twig, as long as the bud, can be seen projecting up the side of this apparently terminal bud—e.g. in the Hornbeam, Plane, and even Willows; in others the end of the twig becomes a pointed dead thorn—e.g. *Prunus, Hippophaë, Pyrus, Cratægus, Rhamnus catharticus.*

The long branches of Oak, Maple, Ash, and Conifers, on the other hand, almost always have terminal buds which normally continue the growth.

A much more common cause of cessation of elongation of branches, however, is their termination in a flower, for, with rare exceptions, the end of the branch included in the centre of the flower ceases all further elongation. Exceptions do occur, however, as shown by the proliferation of Larch-cones (Fig. 8), Pears, and other cases; such proliferation is normal in Cycads. The peculiarities of these floral axes and their branch-systems have already been treated of in dealing with the flower and inflorescence, but inasmuch as each axis of a flower-bud and each flower-stalk is a branch, we may deal with its general nature here.

It rarely happens that the primary axis, or main stem, developed from the plumule ends in a flower during the first year, and then the whole plant dies after scattering the seeds; much more common is the case where the primary axis developes only leaves during the first year, and then grows up rapidly and ends in a branch system of flowers, terminating its life at the end of the second season—e.g. biennial plants such as Foxglove, Mustard, &c.

Cases like that of the Tulip or Hyacinth have to be carefully distinguished from the above. At first sight it looks as if the Tulip flower was a direct continuation of the primary axis: so it is, of the main axis of the bulb, but the latter was itself a secondary axis in the axil of a

bulb-leaf of the year before, and other buds are found in its leaf-axils.

The case is different in degree only where, as in *Corypha* and *Agave*, the main axis developed from the seedling, after producing leaves only and no branches, for many years, is brought to an end by the sudden development of a terminal branch-system, each twig of which is arrested as a flower, and then dies down. This leads us to see that it is only true to say that palms do not branch if we exclude the flowering branches: as matter of fact they produce year after year branch-systems which are devoted entirely to the formation of flowers (inflorescences).

In the vast majority of ordinary plants the course of events is that some branches bear flowers, and usually terminate their growth with them, while others bear leaves in the ordinary sense of the word; and since branches do not occur in the axils or on the nodes of the flower, but are common in connection with ordinary leaves, we are struck with the peculiarities of floral stems as contrasted with foliage stems, even more than with the differences between the ordinary and dwarf-shoots in the foliar regions. As we shall see later, however, one and the same principle lies at the bottom of all the different kinds of branching, and it is only a convention for purposes of expediency which drives us to employ special terms for the cases described above.

That the primary purpose of branching is to expose the leaves or other organs more effectively to light and air may be directly observed by comparing the behaviour of trees, shrubs, and herbs in various situations, and is especially obvious in forests of mixed species where some plants become so over-topped by the more rapid growth of others that they die, owing to their foliage receiving

less light than they are adapted for. Even on single trees in the open we see how the lower branches extend their leaf-bearing tips further from the main axis, in accordance with their greater age, and so avoid the overshadowing of the foliage by the leaves on the branches above.

But it is evident that an intense struggle for existence goes on in both the above cases, resulting in the overshadowing of individual twigs, the starvation of their leaves, and consequent death of the twigs themselves. This suppression of branches brings us to another consideration.

If the plumule, as it developes into the primary shoot, had a bud in the axil of every leaf, each bud in turn growing out as a branch again with buds in its leaf-axils, and so on, it is clear that we should have a shoot-system of very symmetrical habit developed, just as in the typical root-system we should obtain very symmetrical structures if all the lateral rootlets developed equally and met with no obstructions in the soil, differences of temperature, moisture, marauding insects, fungi, &c.

As matter of fact the typical shoot-system does begin its life with remarkable regularity of structure; but very soon the action of the environment on the one hand, and some not yet completely explained internal causes, come into play to stop this formal symmetry. In illustration of the statement that young shoots are very symmetrical the student may examine any normally developed seedling of a Maple, Cress, or Deadnettle.* He will find that a projection of the primary stem and its leaves, seen end on from above, gives a very symmetrical figure (compare Fig. 11), more striking in the case of shoots with opposite leaves than in those with alternate ones, it is true, but still very evident. Many well-grown Christmas-trees

(young Spruces), or Mistletoe, *Stellaria holostea*, Saxifrages, &c., illustrate the same thing, and it is particularly conspicuous in many inflorescences.

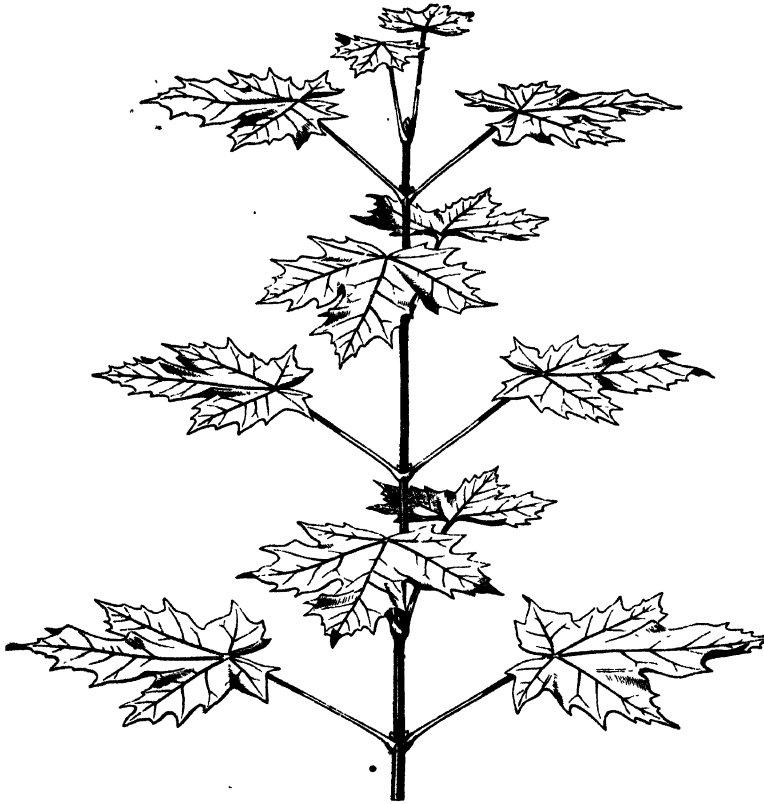


Fig. 11. Erect shoot of *Acer platanoides*, Norway Maple, viewed from the side and from above; showing the decussate arrangement and horizontal display of the leaves (K).

As time goes on, however, as every tree especially shows, this symmetry is rapidly converted into the more

artistic abandon of older plants by the operation of the various influences referred to and the co-operation of others yet to be mentioned.

Apart from the growth of some branches into shoots of unlimited growth, while others form dwarf-shoots, the conversion of others into flowering branches, the arrestation of terminal buds, and so on, we find that many buds are starved at the outset, and never reach the dignity of branches under normal circumstances—e.g. the buds in the axils of the cotyledons of the Broad Bean, which only grow to branches if the primary shoot is removed. In many cases these suppressed buds remain alive (dormant) and later on develope into branches, out of their turn as it were (deferred branches) On the other hand, buds are not as a rule formed in the axils of bud-scales, or if formed do not develope into branches, and the same is true of the lower leaf-axils of most branches, the axils of the floral leaves (sepals, petals, &c.), and on most trees there are numerous buds suppressed in places where we should have expected to find them. The development of buds and therefore branches only in the axils of a few of the numerous leaves on a parent axis is carried out almost symmetrically in its turn in some cases—e.g. the Spruce, Silver Fir, and especially in *Abies Pinsapo*, but it occurs in Oaks, *Pyrus*, and many other trees, and is equally common in shrubs and herbaceous plants.

Nor is this all. Many trees develope branches in the places we should expect to find them, only to cast them off later by a process of abscission very similar to that by which the leaves are shed every autumn. This occurs to a striking extent in *Taxodium*, but it is also universal, or nearly so, in Oaks, Poplars, Willows, and other of our common trees.

We thus see that the branching of the shoot, like that of the root, but to an even greater extent, loses symmetry as time progresses owing to the action of the environment; but, apart from this, the branching of shoots is much more complex than that of the root owing to the much more varied functions performed. As we shall see, the same is true as regards the modifications and adaptations they undergo.

CHAPTER III.

BRANCHING.

Branches and axes of different orders—Branching of the root—Branching of the shoot—Normal and Regular branching—Induced irregularities—Adventitious branches—Accessory buds—Dichotomy—Monopodial axes and racemose or indefinite branching—Sympodial axes and cymose or definite branching.

THE word branch as ordinarily used expresses the scientific meaning of the term so closely that we may accept it without further definition — the branch resembles the axis which produces it, as shown in branching stems, roots, leaves, &c. The only difficulties which can arise are where the branches, though morphologically of like kind with the axis producing them, undergo modifications which result in their appearing to be different from the axis, as will be considered when we come to speak of the adaptations which branches may be subjected to.

While branching is very common, it is by no means universal either in the shoot or the root, and in the case of many organs branches are exceptional, e.g. the parts of the flower, adventitious roots, &c.

The idea of a branch presupposes that of the axis which bears it, and if we speak of the latter—root, shoot, leaf, &c.—as a primary axis, then the branches borne

on this may be termed secondary axes, but in their turn primary with regard to branches they themselves bear. We thus come to regard branches as of various degrees or orders, and speak of a primary axis bearing branches of the first order, any of which may bear branches of the second order, these branches of the third order, and so on to any extent, as exhibited by the ramification of most trees into limbs, branches and twigs. Or we may speak of primary, secondary, tertiary, &c. branches.

It will thus be seen that when we find a stem bearing leaves only, our reason for not calling this a branched stem is that the lateral appendages (leaves) are not of like kind, and it would appear to be a very simple matter to determine every case by direct observation were it not that comparison shows that careful examination is frequently necessary to decide whether a given lateral appendage is or is not fundamentally similar to the axis producing it.

In the case of the typical branches of ordinary stems or roots no difficulty arises. Each primary root developes secondary roots, of like kind, and each secondary root may develope tertiary roots in like manner, and so on; and it is characteristic of typical roots that they only bear lateral organs of like kind—i.e. they branch, but do not develope other appendages.

With the shoot-system matters are more complicated, however, in accordance with its more variable environment. Not only does it support very different kinds of appendages, especially leaves and their modifications and the reproductive organs, but its branches undergo so many alterations in form, position and relations of various kinds, that we have sometimes to be on the look-out for very definite criteria to guide us in determining what are and what are not branches.

Taking the simplest and commonest cases first. Ordinary branches arise in the axils of the leaves, by the elongation of the buds, and themselves bear leaves with axillary buds, as we have seen. Consequently, as regards position, the branches follow the same rules as the buds, and if every leaf-axil developed its normal bud and subsequent branch, we should have the branching perfectly regular, a case never realised though some approach to it occurs in a few instances, e.g. young Maples, Horse-chestnuts, &c. with opposite branches, and Apples, Poplars, &c. with alternate branching.

If the primary axis goes on growing in length and developes branches—secondary axes—in normal succession, so that the youngest and shortest are nearest the growing point, on the flanks of which all normal appendages arise in the first instance, we find the whole branch-system tapering, and the order of succession of the branches is said to be *acropetal*. This case is well illustrated by young and vigorously growing Pines, Spruces, Silver Firs, &c. If each branch so produced grows on normally, the whole may result in very regular figures, whether a branch arises in most or only in a few of the leaf-axils, e.g many Conifers and young flowering plants generally; but it is obvious that accidents of various kinds—e.g. breakages by wind or snow, injuries by insects or other animals, &c.—may stop the development of one or more branches at any age from its bud-state onwards, and at once introduce disturbances in the symmetry. It is owing to such causes that older trees are never regular, and the same applies to the root-system, the symmetrical development of which is interfered with by various exigences met with in the soil, such as mechanical obstacles, dry patches, clay, injuries by insects, &c.

It frequently happens, moreover, that only a certain number of the buds formed come to development owing to the struggle for existence due to their competition for nutriment. A rapidly growing branch may use up so much material, and so divert the flow of water and food-materials to its own leaves and buds, that neighbouring buds are starved out as it were, and either die off altogether and are suppressed, or remain dormant and undeveloped for a longer or shorter time, and thus another common cause of irregularity of branching is introduced. Examples occur in the Lilac (Fig. 12) and Horse-chestnut, where the terminal bud is often suppressed in this way and two lateral opposite buds just below continue the growth as if the stem was forked, or the terminal bud

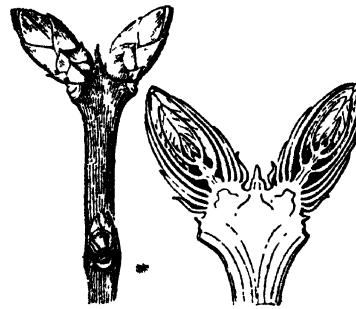


Fig. 12. Lilac. Figure to the left shows the reduced terminal bud and the two large lateral buds: that to the right shows an enlarged vertical section of the same (Wo).

grows on while one of the laterals buds is starved, or grows more slowly, or both suffer retardation, or even destruction, with permanent effect on the regularity of the branching.

When new buds or shoots are developed out of their proper order, we have *adventitious* as opposed to *normal* branching, a common phenomenon in cases of injury or of

very luxuriant growth—e.g. in Willows and Poplars, Elms, &c.—and this is another common cause for non-symmetrical ramification. Of course the regularity is also interfered with when *accessory* or extra buds are formed side by side, or superposed, and develope into branches, and when branches, already developed, are cast off as described on pp. 32 and 43.

The student must not conclude that all branching is brought about by the formation of lateral outgrowths behind the apex, however, or that all the branches of the shoot-system are necessarily axillary structures.

It occurs rarely—chiefly in certain lower plants such as vascular Cryptogams, Hepaticæ and Algæ—that the vegetative cone stops its onward growth as a whole, and proceeds to grow equally in two directions inclined at some small angle to the original one: as if a knife edge were held exactly on the apex, and growth proceeded right and left of this. In these cases the stem becomes forked, and the branching is said to be *dichotomous*, but true dichotomy probably never occurs in the higher plants, where the branching is always lateral, however deceptively like dichotomy the cases of the Lilac, Horse-chestnut, Maples, &c. referred to above may appear.

The branching of the shoots of many Ferns and lower plants again is by no means always, or even usually axillary, though it commonly starts from the leaf-bases: in flowering plants however, apart from the examples cited of adventitious branching and the development of accessory buds, the rule is that one branch arises in the axil of each of the many or few leaves concerned.

An important cause of variety in the normal axillary branching of the typical shoot depends on the relative rapidity and duration of growth—i.e. elongation—of the branch and its parent-axis.

If the parent-axis maintains its rate of elongation, and the lateral axes, in acropetal succession, go on growing uniformly, or nearly so, it is clear that the whole shoot-system consists of one primary axis and its appendages, and has a more or less conical or pyramidal outline according to the angular divergence and directions of growth of the laterals—e.g. young Pines, Firs, &c. already referred to (Fig. 1).

Nor is the matter essentially altered if the primary axis grows less rapidly than the laterals, and these come to over-top it in time, though in this case the whole outline of the shoot-system is altered.

The fundamental fact here concerned is that there is only *one* primary axis, which, continuing its onward growth, throws off secondary lateral axes which grow out at various angles from it. This on-growing primary axis is often termed a *Monopodium*, and the total branch-system thus developed is frequently termed *Racemose* or *Indefinite*—the latter term referring to the continued on-growth of the primary axis. Of course no difference in principle is introduced when the secondary axes bear tertiary ones, and behave similarly, and so on with higher orders of branching, as is well seen in many Conifers during the first twenty or thirty years of growth, during which the regular pyramidal-conic form is maintained, each lateral branch growing proportionally equally as the leader elongates.

An essentially different system of branching is met with, however, if the primary axis stops growing by the death of its vegetative apex, while the secondary axes continue their onward growth, and many of the most interesting and difficult forms of branch-systems are due to this phenomenon.

A simple case is afforded by the branches of a Lime or

Elm. If we examine the tip of a Lime-twig in autumn, just as the leaves are falling, we find a leaf with its axillary bud close behind the terminal bud of the twig; but this axillary bud is large and vigorous and will grow out next spring, whereas the true terminal bud is small and shrivelled, and will not grow out (compare also Fig. 9). In other words, the apparent on-growth of the branch next year is *only* apparent—each annual addition to the length of the branch is really the growth of a lateral branch, the axis of which comes practically to coincide with that of its primary axis. The totality of these growths make up a *Sympodium*, and the mode of branching is frequently termed *Cymose* or *Definite*, the latter term referring to the early arrest of the primary axis.

It is of no importance whether the arrest of the true terminal bud is due to exhaustion and direct death, or its conversion into a thorn, tendril, flower or other organ, so long as the process is normal in the species; though it is obvious we could convert any Monopodial branch-system into an artificially Sympodial one by periodically nipping or cutting off the terminal buds, and this is done to a large extent in the pruning of fruit-trees, the curious branching of which is entirely modified by the cultural operations. But exactly similar effects are produced in Nature by the pruning operations due to death of the terminal buds or tips of branches, or the destruction of whole twigs or shoots.

CHAPTER IV.

BRANCHING.

Causes of irregular branching—Wiesner's observations—Branch-casting—Part played by animals and fungi—Influence of light and shade—Correlation—Polarity—Action of gravitation—Internal causes of organization—Action of wind in temperate and Arctic countries—Mechanical action of wind.

I HAVE now to examine further causes of the irregularity of branching which prevails in actual trees.

These causes may be grouped under two distinct heads.

First, there are the specific alterations in the arrangement and numbers of buds and the kinds of shoots they produce, which are due to internal and inherited dispositions and actions in the plant: some of these actions consist in the definite riddance of shoots already formed.

Secondly, there are all the varied actions of the environment, due to drought, wind, rain and hail, snow and ice, &c., and the attacks of other living beings which kill buds, break branches, &c. and obviously destroy the symmetry by mechanical and other means.

Both these sets of agencies may co-operate in limiting the growth of particular shoots, or in stimulating that of others, or in altering the directions of growth of young

shoots, either by the displacement of buds or by directive action during elongation.

Some of these points have been indicated before, but we will now examine them in more detail, and with specific examples.

Some very striking examples of the departure of an older branch-system or leaf-crown from the normal that would result if all branches persisted, have been collected by Wiesner.

An Oak-tree 100 years old would have 99 generations or orders of branches if all persisted: as a matter of observation only five or six could be found. A Plane-tree 50 years old would have 49 orders, but only seven could be detected.

Any one can easily make out similar results for himself if he examines the twigs and branches of any ordinary tree, bearing in mind that the year's growth is defined by the intervals along the axis between any set of bud-scale scars and the next, or the terminal bud. Or, to put the matter in a slightly different form. If a branch of Birch developed two lateral shoots the first year, and in each successive year each of these laterals and its parent-shoot repeated the process, the whole branch-system at the end of ten years should exhibit nine orders of branches bearing altogether 19,683 foliage bearing twigs; but Wiesner was not able to trace more than 238 such twigs on a well-lighted branch of Birch ten years old, and a shaded branch of the same age only showed 182; and in both cases, instead of nine orders of branches only five were to be found.

Apart from the stem and the buds, Wiesner points out that our native trees never show clearly more than eight orders of branches (Hornbeam, Beech, Yew) and usually not more than six orders.

Now if we accept these results as facts to be discussed —and their substantial accuracy is easily proved by observation—it is clear that either some wholesale destruction of branches must have occurred during the development of the tree, or some agency must have been at work to prevent the formation of the expected branches.

Investigation shows that both causes are at work—ruthlessly weeding out of the shoots either at their inception in the bud-stages or at later periods in life, and the principal purpose of this chapter is to show how this comes about, and what are its immediate consequences to the tree.

Numerous trees cast branches periodically either in the stage of young shoots or twigs, or even later in life. This process of branch-casting is exactly comparable to that of leaf-casting, and is brought about by a similar succession of normal phenomena. That is to say a layer of thin-walled cells, a true absciss-layer, is formed across the twig or branch, and the middle plane of this layer constitutes a plane of weakness at which the upper part of the twig breaks away from the lower, the surface of separation being covered by a layer of cork, which at once distinguishes the former from a mere wound. It is the early inception of such a layer which makes the twigs of *Salix fragilis* so brittle at the articulations.

It is a common experience in summer and autumn to find the ground beneath such trees as Pines, Oaks, Elms, Walnut, Ash, Maples, Poplars, Willows &c., littered with twigs or even long shoots which appear to the uninitiated to have been blown off by wind or cut off by squirrels or other animals: careful examination of the surfaces of separation, however, shows that the process has been the natural one of branch-casting, due primarily to internal agencies, though of course the phenomenon may

be aided or intensified by external factors—e.g. the Oak often casts numerous twigs after a hot summer, and the fact that large quantities of starch may be shed in these, and that the tree may bear a heavy crop of acorns the same autumn, invalidates any belief that the casting is simply due to starvation or weakness, although it appears to be true that drought, age, and especially feebleness of growth on poor soils exert their effects; in the Oak it is chiefly weak lateral shoots which are first cast. Young trees on good deep soil often defer the casting for many years. Indeed it is the rule that young Oaks, and Limes, Planes, Hazel, &c., do not cast branches normally; but even vigorous young Oaks and Limes may thus cast their terminal shoots.

The amount and kind of branches thus cast, and the position of the planes of separation (absciss-layers) on the shoots, vary in different species. For instance the Scots Pine casts needle-bearing dwarf-shoots several years old, and it may be taken as a rule that it is dwarf-shoots which are cast by most trees. But the latter statement expresses no universally applicable rule, for Poplars and Willows cast long-shoots from one to six and even more years old, three feet or more in length, and the Oak may shed twigs two feet long. Even the inflorescences may be cast with the current year's shoot in Willows and *Prunus Padus*.

In Oaks and Poplars the position of the absciss-layer is at the base of the cast shoot, but in Willows and *Prunus* it may be situated above the lowermost undeveloped leaves.

That this curious phenomenon must play a part in modifying the shape and symmetry of the branch-system or crown of the tree is obvious.

It has been pointed out that the very loose structure

of the crown of the grey and black Poplars, and the peculiar whip-like denuded character of the twigs of the latter and of Willows, are due to branch-casting; and the same operation plays an important part in determining the knotty and gnarled appearance of the Oak.

In some trees the process of branch-casting begins as early as July but in others it prevails in August and September or even into late autumn, and variations are observed in both individual trees and seasons. In *Taxodium* the casting of the leaf-bearing shoots has become annual and replaces the phenomenon of leaf-fall characteristic of deciduous trees.

It is not to be assumed, however, that all trees show the process of branch-casting above described: apparently the Spruce and Silver Fir are cases in point. Moreover, by no means all the litter of fallen twigs and branches found beneath trees which do cast branches, are due to this phenomenon. Squirrels, birds, and insects often play their parts—often causing great havoc, for instance in the crown of the Scots Pine.

But even more powerful in its effects than all these agents, is the killing action of shade, a subject to which I must now turn for treatment in some detail, since it is the great factor in shaping the crown of the tree.

All green leaves are organs adapted for exposure to light and air, and only when properly expanded in a suitably illuminated atmosphere can they supply the twigs which bear them, and through these the other parts of the branch-system and tree, with food-materials. Consequently all shade beyond a certain tolerable degree is fatal to the leaf-bearing shoots and results in their poor nutrition, in starvation of their buds and tissues, and in short in their enfeeblement in the competition with other foliage-shoots in the immediate neighbourhood.

No physiological observation is better established than that any foliage-shoot which persistently throws a deep shadow on another similar shoot, at once places the latter at an enormous disadvantage in the struggle for existence. The sufficiently illuminated and aërated shoot dominates the over-shaded one, and it is only a matter of time how long the latter can hold out at the expense of the supplies stored up in its tissues.

Two very direct consequences of the competition of shoots for light are seen in the paucity of foliage or even total lack of leaves in the interior of the crown of a tree, and in the "cleaning of the bole," as foresters term it, when the stem is sufficiently over-shadowed by its own foliage or by that of other trees. Different trees differ considerably in the amount of shade they will bear, or, what amounts to the same thing, in the degree of intensity of light which suits them best. For instance, the Birch, with its sparse foliage on relatively few branches, stands in marked contrast to the Beech with its densely foliaged and crowded branches. The former casts a very feeble shade in which numerous flickers of sunlight play, and almost any tree can withstand its shadow, whereas it is itself very intolerant of shade. The Beech on the other hand casts a dense dark and cool shade, beneath which scarcely any plant can grow, and is itself capable of enduring for a long time the shadows of most other trees. Similarly with the Larch and the Yew, the former of which casts the lightest and least sustained of shadows among Conifers, partly owing to the loose and open arrangement of its foliage and partly because, being deciduous, it is devoid of leaves from November to April or even longer, whereas the Yew is evergreen and casts a deep shade owing to its evergreen and densely crowded foliage.

Foresters are accustomed to term the Birch and Larch and similar trees "light-demanding" as contrasted with the "shade-enduring" Beech, Yew, &c., and they arrange ordinary forest trees in some such category as the following. Generally speaking it is found that the Larch, Scots Pine, Birch and Aspen demand more light than the other pines, the Maple, Sycamore, Oak, Ash, Chestnut, Elm, Alder and Willows; and that the Spruce, Silver Fir, Hornbeam, Beech and Yew are capable of enduring more and more shade.

It must be carefully understood, however, that no single species is absolutely fixed in such a category as the above: differences in age, vigour, situation and soil, latitude and altitude, &c., all have their effects in enabling any particular tree to withstand shade better or worse than usual. All we can say is that, other conditions being equal, the species at the head of the list require freer exposure to the light of the particular locality than do those towards the bottom of the list, and care must be taken in planting such species in mutual proximity that light-demanding trees are not dominated by shade-enduring species.

Moreover, we must not forget that a tree is a sensitive organism, and may be exposed to too intense as well as to too feeble a light for health.

There are a series of phenomena, as yet but partially and vaguely understood and regarding which our ignorance is expressed in the term correlations, which nevertheless play important parts in the shaping of trees.

If two long shoots of a Willow are cut and hung up, one so that its basal end is uppermost, the other in the normal position, both in moist air and similarly treated in every respect other than position, new shoots arise at the end nearest the tip and roots at the basal end in both

cases, and since this occurs even with short lengths cut off the shoot, we seem to be justified in speaking of a root-pole and a shoot-pole respectively; yet there are a few cases where the bent-down tip of a long arched shoot appears to give origin to roots, and in some cases roots can give rise to shoots.

But the most striking result in such an experiment is the sequel: whatever the position of the hanging mother axis, the shoots put forth always turn up at the tip and grow out at an angle which is acute to the vertical above the insertion: the roots at the same time growing down towards the ground.

That these phenomena are in some way due to the action of gravitation, is proved by experiments into the detailed nature of which we cannot here enter, but regarding which it may suffice to say that if we so rotate the plant or organ concerned—on a slowly revolving instrument driven by clockwork, and known to plant-physiologists as a Klinostat—so that every side of the growing organ is for equal small periods equally exposed to the vertical action of gravitation, no such constancy of angular divergence is assumed: the organ merely grows out in the direction it happens to be in on its first emergence from the bud. But although gravitation is a principal factor in determining the direction of growth of a shoot from an axis which is a rest, the phenomenon cannot be wholly explained by geotropism—the term applied to this reaction.

Take the case of almost any tree growing in the normal position. The buds on the leader in most cases point so that their tips form less than a right angle with the parts of the axis above them: we may neglect for the moment a few trees and shrubs from which the buds stand out at right angles, as in certain Honeysuckles, and

confine our attention to such cases as the Willows, where the buds are appressed and point almost or quite vertically, or to Spruce, Beech, &c. where the angle of divergence is near 45°.

When the young shoots emerge they come off at angles not far from 45° with the vertical leader, and will maintain that angle for many years as they thicken to branches, often bending over at a wider angle later owing to the weight of the foliage.

But how is it that, while the buds and their shoots on the main vertical axis of the leader thus point upwards, at an acute angle with the vertical, those on the lateral nearly horizontal shoots also point out at an acute angle with the axis which bears them, and in many cases grow out at such angles but in the horizontal plane?

The phenomenon is common enough. The buds and shoots on the main stem of a Beech or Lime, for instance, all point upwards, at acute angles not far from 45° with the vertical axis above them: moreover, they are spirally arranged on that axis. But the buds and shoots on the overhanging and nearly horizontal lateral branches of the same tree point outwards, at a similar angle with the part of the axis bearing them but nearly in the horizontal plane, approximating to the plane in which the parent axis grows: moreover, these buds and shoots are here not spirally arranged, but right and left on the axis —i.e. distichous.

Yet these distichous, horizontally directed shoots can be made to develope spirally arranged and upwardly directed buds and shoots by artificially fixing the parent axis in the direction of the vertical. In other words, by altering the position of the shoot-axis, we can induce it to produce buds, leaves and shoots disposed in a totally different manner from the normal to the

said axis, as regards their relation to the vertical; and here again, experimental enquiry leaves us no loop-hole of escape from the conclusion that gravitation is at the bottom of the phenomenon, since that is the only known factor of the environment with which we have interfered, and that, of course, only in so far as concerns its direction of action on the shoot.

Nevertheless, this does not exhaust the subject. The youngest lateral branches below the tip of the leader of a Pine, Spruce, Beech, &c. shoot out into the air at an angle with the vertical of somewhere near 45°: as they grow older this angle widens, doubtless due to the increasing weight of the foliage, &c. they have to support, until older branches may either arch over or even form an angle greater than 90° with the vertical axis above the insertion, the tips curving in various ways.

But this initial angle of divergence, of 45° or less, is at once altered if we remove the leader by cutting, or if it is broken off by wind, or destroyed by some parasite, &c., and the previously diverging shoots are found to erect themselves vertically, until one, favoured by circumstances and stronger than the others, usurps the functions and peculiarities of the lost leader. Here we have an excellent example of what, in our ignorance, we term the correlation between organs. It is important to notice that not only does the position of the newly constituted leader change, but the whole sequence of events in its life is altered: its leaves, buds, branches, &c. are all henceforward differently disposed from what would have been the case had the shoot continued its life as a lateral organ.

It is impossible to believe that geotropic influences alone—i.e. the directive effects of gravitation acting at certain angles on the growing organ—are the only factors

here concerned, even if we had no further evidence. But we have further evidence, for exactly such erections of axes normally horizontal, with all the ensuing changes in position and direction of leaves, buds, branches, &c. are evoked in shoots of Silver Firs, &c. by the irritating action of certain parasitic fungi.

We are therefore driven to the conclusion that, while gravitation undoubtedly plays an important part in the arrangement and direction of growth of the shoots and branches of the tree, its effects are always contingent on other actions due to causes hidden in the organization of the tree, and which, for want of a better phrase, we term internal causes.

That there are other factors of the environment which affect the shaping of trees will be obvious to all who have understood the significance of normal branching, and the possibilities it offers to interfering agents. When one reflects that every time a boy, intent on bird's-nesting, crushes a twig or bud with his feet or breaks a bough in his climbing, he destroys not merely the bud or shoots directly concerned, but also all the buds and shoots incipient in them: that every time a bullfinch picks out the heart of a black-currant bud, or an insect lays her egg in a bud, or a squirrel nibbles off a Spruce-shoot, and so on, the damage done is irreparable so far as the exact symmetry of the tree is concerned.

The shaping action of pruning operations, whether they take the form of mere shearing of a hedge, or carefully devised cuttings of valuable fruit trees, teach the same lesson; and here I may say a few words anent Nature's great pruning agents, wind, frost, snow, &c.

Every visitor to the seaside, or to wind-swept districts of any kind, is familiar with the peculiarly shorn appearance presented by hedges and trees of all sorts exposed to

the prevailing blasts. The trees or bushes are all stunted and smoothed off, as it were, on the windward side, and more or less drawn out or hanging over towards the sheltered side, and the opinion is very popular that the force of the wind has blown-over the shoots so that they come to lie in the direction in which they mainly point.

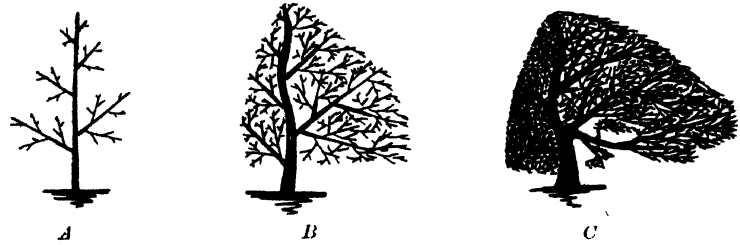


Fig. 13. Diagrams to show the effect of wind on tree-form.

But this is not the explanation of the fundamental phenomenon at all. Let us suppose the diagram *A* in Fig. 13 to be a tree henceforth exposed to prevailing high winds from the west. In course of time the twigs and branches facing the west are found to be much more stunted than those on the sheltered side towards the east, as seen in *B*, because the drying action of these prevalent high winds has killed many of the buds by over transpiration, and each bud killed means so much shoot-system the less. On the sheltered side, however, there has been less destruction of buds and a corresponding outgrowth of longer shoots, with more successful buds, developing again to longer shoots more richly supplied with buds, until at length the state of affairs diagrammatically represented in *C* is attained, where the extensive growth towards the east is more and more pronounced according to the sheltering influ-

ence of the dense rampart of stunted twigs to the west behind which the buds can develope[1]. The face of this rampart, exposed to the full force of the wind, looks as if it had been sheared: and so it has, in a certain sense, but the pruning action is more properly compared to the nipping out of innumerable buds by the fingers, as in the horticultural operation of "disbudding," than to the actual cutting of shoots already in existence. This apparent shearing action extends over the top and for some distance down the eastern side, in proportion as the winds strike downwards, but the result shows that the action is more and more feeble as it descends the long slope.

The general appearance of the shrub also suggests a mechanical blowing over of the twigs towards the east, and no doubt long continued winds during the season of growth in length do blow over the shoots, but the general resemblance to tresses of hair borne out by the wind is deceptive.

In the Arctic regions it has been shown that such apparent shearing actions of the dry cold winds occur over all parts of the bushes and trees exposed above the winter covering of snow, and the height of the plants is limited by the average depth of the snow covering during the winter: every twig which projects beyond this covering has its buds killed by drought, not by cold, for although too low a temperature will doubtless kill any bud or shoot if moist, there is no reason to doubt that the twigs and buds of Arctic shrubs such as Birches, Junipers, Firs, Pines, &c. could withstand the mere lowering of the

[1] [The preceding description and the accompanying diagrams should not be regarded as giving a *general* account of the effect of wind upon tree-shape, as I have never met with an example of the type here described. P. G.]

temperature for long periods, provided they are dry and thoroughly ripe.

Wind, snow and beating hail undoubtedly do much damage to the crown of trees and shrubs by mechanical breakages, and by weighing them down till fractures result, or by bruising the buds and twigs, and it has been pointed out that the whipping action of Birches in high winds may so injure the twigs and branches of surrounding trees, that an important gain of area may result, and it is quite true that these mechanical injuries have their effects in modifying the shapes of trees, &c.; but the alternate actions of wet and frost, and the desiccating action of cold dry winds, are more important in the connection here discussed.

CHAPTER V.

BRANCHING.

Origin of shoots on old stems and branches—Epicormic branches—Stool-shoots—Suckers - - Epicormic branches — Origin from dormant buds—Trees producing them—Stool-shoots—Origin from callus—Trees producing them—Suckers—Origin within roots—Trees producing them—Trees not producing suckers.

WE have now seen from the foregoing, and from the discussion of buds and shoots in Vol. I., that the initial disposition of the buds on the twigs, their development into long- or dwarf-shoots, the casting of shoots already developed, and the occurrence of accessory and of adventitious buds, with the resulting after-formation of branches in unexpected places, are all factors of importance in the determination of the mode of branching, and therefore in the shaping of the tree; while the initial angles of divergence of the shoots, and their subsequent curvatures and changes of direction due to the action of light, gravitation, wind, and other factors of the environment, also play prominent parts in deciding the ultimate form of the branch-system.

It is now time to consider somewhat more in detail the origin of shoots on old stems and branches, which bear no obvious relation to the normal buds of the tree, or in

some cases even to the regular alternations of nodes and internodes on the twigs and branches.

When an old tree is suddenly exposed to freer access of light and air, by the felling of its hitherto closely crowding neighbouring trees; or when such a tree suffers severe pruning by the knife, or by the loss of a large limb by breakage under the leverage of wind or the weight of snow, it is a common result that the old trunk rapidly puts out innumerable shoots—"Epicormic branches"—which push their way apparently through crevices in the bark. The question is, whence arise these shoots, or the buds from which they spring?

Before answering this question, we may put another case.

It frequently happens that when an old tree is felled, or when the wheel of a heavily laden cart severely abrades the base of the trunk of a vigorous standing tree, multitudes of buds, followed by the outgrowth of crowded shoots—"Stool-shoots"—make their appearance from the cut or injured tissues in close proximity to the wood.

And yet a further case.

Every grower of fruit trees and roses knows that many old trees of such species as Plums, Pears, &c., or of Roses budded on briar stocks, are apt to send up vertical shoots —"Suckers"—from the soil around, at such a distance from the stem that he has no escape from the conclusion that they have sprung from the roots radiating into the area round the tree. In many trees—e.g. the Robinia, White Poplar, &c.—such "suckers" may arise from the roots long after the death or removal of the superterranean parts of the tree, and even after an interval of time long enough for the memory of the tree to have passed away: in some cases these suckers spring up many feet distant from the tree, or from the spot where it once stood.

The three sets of cases here postulated are quite different, and the difference in terminology is justified by the facts as to the origin of the "Epicormic branches," "Stool-shoots" and "Suckers" respectively. Only in the sense that the buds giving rise to them are out of their proper order in the symmetry of the tree are they to be referred to as adventitious; but the manner of their being so is quite different in all three cases.

If we carefully examine the place of origin of the buds giving rise to epicormic branches, on a tree trunk or limb, it may often be seen that they arise from the crevice behind the crest of an arcuate cushion, which slightly projects from the surface of the bark: this cushion is all there is left to show where, years before when the limb or trunk was a mere twig, a leaf-scar existed, and the crevice behind it was a leaf-axil. In other cases the cushion represents the inequality in the surface of the bark due to the pressures exerted by a thickening axillary branch. In the former case the bud is really arising in an old leaf-axil: in the latter it is arising from the extreme base of what was years ago an axillary branch.

But what is a bud, now about to develope a shoot, doing in such a position? why did it not long ago grow out to a shoot, which, judging from the age of the parts concerned, should now be a stout branch many years old?

The comparison of large numbers of cases points to the following as the explanation. When, years before, the bud in the leaf-axil, now only indicated, should have developed into a shoot, the competition for water and food of other buds in the neighbourhood resulted in its partial starvation, so that it was unable to put forth even so much as a dwarf-shoot, and it remained a bud, but did not die.

Such a bud, so long as it retains its original vascular connection with the wood of the parent shoot-axis (Fig. 14 I *w'*), may go on living for many years, elongating just sufficiently to keep its head above the outer surface of the axis, as shown in the diagram (Fig. 14 II), where we see the branch has now put on 19 annual rings of wood in addition to the first year's wood of the shoot (*W* in Fig. 14 I).

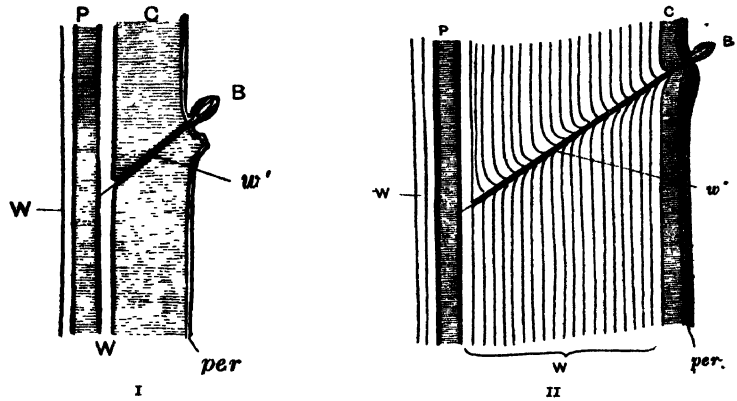


Fig. 14. Diagrams of longitudinal sections through a branch and its dormant bud, in the 1st and 20th years respectively. *B* the bud; *W* the wood; *w'* connection of bud with wood; *per* periderm; *C* coxtex; *P* pith.

So long as the powerful and increasing system of branches above this bud retains its dominance over the supplies of food-materials, the general flow of the latter will pass by the bud *B* and its vascular connections *w'*, and it will be as much as the latter can do to just keep the bud alive and permit of its slow growth necessary to keep its head at the surface; and, of course, it may happen at any time that further deficiencies in the

supplies may bring about the death of the bud, and the same result will follow if the slender conduits for water and supplies *w'* are severed so as to cut off the bud from its connections with the general vascular system.

If, now, from any cause whatsoever, the upper parts of the tree begin to make less strenuous calls on the general supplies of water and food-materials in the wood-system *W*, or if the foliage as a whole is suddenly enabled to supply more food-materials and to attract more water into this wood-system, then the bud *B* has an opportunity of obtaining a larger share of supplies than was hitherto the case, and can forthwith put out a shoot on its own account, the leaves on which will henceforth afford supplies sufficient for the further development of such shoot, and of the buds formed on it, and thus establish it as a perfectly normal but belated member of the branch-system.

It is easy to see what circumstances may bring about these events: the cessation of growth in height as the tree reaches its maximum stature; the dying off of the uppermost twigs during a drought; a serious wind-breakage or fractures from heavy loads of snow or ice; all or any of these would lead to a diminution of the upward draught of the supplies in the wood at *W*, and so leave more to spare for the feeble draught exerted by the bud conduits at *w'*. On the other hand, a sudden access of increased light and air to the crown of the tree, consequent on the removal of neighbouring trees, would have two principal results: increased supplies of water from the roots, owing to the removal from competition of the roots of the absent trees, and increased supplies of food-materials from the now better illuminated and aërated leaves, so that again there would be more to spare for the bud *B*.

It is also probable that in the latter case the increased warming and illumination of the stem and the bud itself act as stimuli to its development, and in any case such must act beneficially on the first leaves put forth from the bud.

I have so far considered the bud *B* as a true dormant axillary bud. The case is not materially altered when, instead of the true axillary bud we have at *B* one or more minute dormant buds which had originated years ago in the axils of the bud-scales of the then axillary bud; or when, at the base of a shoot developed in the axil but which never came to anything conspicuous, one or more minute buds were formed and kept alive in the same manner, as suppressed or dormant buds. The vascular connections will then be somewhat more complex than in the diagram (Fig. 14), but the principle is exactly the same. Since this book is not concerned with anatomical details, further than those needed to explain the external features, I pass these by, merely contenting myself with pointing out that in most cases the epicormic branches arise in tufts simply because the primary dormant bud, during its years of suppressed life, usually manages to form a number of such minute microscopic basal buds in the axils of its bud-scales and basal leaves, and in some cases even accessory collateral or superposed buds as well. For further details of these the reader is referred to Vol. I.

Epicormic branches, then, are normally due to truly dormant buds, which are there all the time but so minute and suppressed that the successive layers of periderm and bark have practically invested them and nearly covered them up.

The case of stool-shoots proper is quite different. It is true that in many instances, especially in those known

as coppice, the felling of a tree by the axe or saw employed close to the surface of the soil, results in the rapid development of coppice-shoots from dormant buds at the very base of the stem or trunk. These are explained by exactly the same reasoning as we applied above to the ordinary epicormic shoots; and the same applies to pollarding, where the rapid succession of shoots from dormant buds at the base of the long branches cut off some feet above the ground, soon results in the formation of a new crown of branches. Pollarding and coppice—and we include Osiers in the latter—are [sometimes] merely particular cases of the development of epicormic branches from dormant buds, it being of no importance here whether the dormant buds are situated at the base of a branch, on the course of the stem, or at the very base of the latter.

The following trees are more or less easily induced to form epicormic branches:

Beech	Elms	Ash
Alder	Scots Pine	*Robinia*
Silver Fir	Oaks	Maples
Hornbeam	Poplars	Birch
Spruce	Larch	

True stool-shoots, however, arise from the wounded tissues of the cambium, phloem, medullary rays and cortex, exposed at the cut surface.

Such wounds are followed by a rapid increase of the cells beneath the injured surface, which grow out in the form of a soft succulent cushion-like covering known as a callus, for the detailed formation of which the student may be referred to my book on *Timber and Some of its Diseases*. Here it must suffice to point out that the buds which give rise to true stool-shoots are formed *de novo* in the tissues of the callus, and are not in any way due to

pre-formed or dormant structures. Each such bud as it is developed at once breaks through the outer covering layers of dead cells and cork formed over the callus, and grows forthwith to a new shoot.

It will be noticed that in a true dormant bud the pith is continuous with the pith of the branch bearing it: a practical distinction between such and true adventitious buds is that this is not the case in the latter.

Stool-shoots are readily developed by:

Poplars	*Robinia*	Hornbeam
Horse-chestnut	Alder	Chestnut
Prunus Padus	Oak	*Euonymus*
Apple	Willows	Elms
Lime	Beech	Ash
Cherry	Birch	Hazel
Pear	Mulberry	

The case of true suckers is very similar, the principal differences being that the buds are developed in the deeper tissues of the root, and that injuries are not always necessary for their inceptive stimulus.

Suckers are developed with readiness from the uninjured roots of still standing trees or shrubs in:

Poplars	Hawthorn	*Euonymus*
Dogwood	*Ailanthus*	Blackthorn
Rowan	Privet	*Robinia*
Tulip-tree		

In the following, suckers frequently follow injuries to the tree, or to its roots:

Elms	Cherry	Pear
Horse-chestnut	Planes	Apple
Pyrus torminalis	*Pyrus Aria*	Raspberry
Spiræa	Alder	*Prunus Padus*

Maple	Chestnut	Hazel
Lime	Birch	Walnut
Lilac	Rose	

The following rarely or never form true suckers:

Oak	Hornbeam	Sycamore
Tree Willows	Beech	Ash
Norway Maple		

It is hardly necessary to point out that the whole of the complex art of pruning illustrates what has been said above. The object of the pruner's art is to increase the branching in places where the competition of the shoots which he removes would, did he allow the latter to remain, cause more or less complete starvation of particular buds. It is true that he aims especially at stimulating fruit-spurs or flowering-shoots—i.e. dwarf-shoots—but, incidentally, he comes into contact with all the phenomena above described. Since pruning trenches on the subject of wounds and their consequences, a theme outside the scope of this book, I cannot enter further into the subject here.

CHAPTER VI.

FORM OF THE TREE.

Columnar form of Lombardy Poplar and Cypress — Elongated conical form of Pines and Firs—Transition to cylindroidal form of Silver Fir—Transition to ovoid or oblong form of Pines—Broadly pyramidal-conic form—Change to umbrella-like form—Apple-type—Type of Rowan, Willow, and Lime—Development of Pine-tree—Development of the Maple-type—Development of Lilac-type—Development of the Horse-chestnut-type—Development of the types of the Rowan, Willow and Poplar, Lime, and Hazel—Development of the types of Plane and Oak.

PROCEEDING now to an examination of the forms of trees, it has long been obvious to all observers that several common types of form may be based on the general contour of the crown of foliage, or, in the case of deciduous trees, of the head of branches.

Many trees are relatively tall and narrow, and conform to shapes represented by a columnar or more or less cylindrical obelisk, gradually tapering from a slightly dilating or broadened base to a somewhat narrower or even tapering apex. Striking examples are the Lombardy Poplar (Fig. 4) and the Cypresses (Fig. 3). But a tendency to the same general outline is also common among Pines and Firs, usually modified in so far that the

tapering from base to apex is more pronounced and gradual, approaching the form of a narrow elongated cone (Fig. 1). Close examination of the cases cited shows, however, that the general form is arrived at very differently. In the Lombardy Poplar and tall Cypress, the main stem gives off branches, and these twigs, which stand almost erect and approximate one against the other more or less like a huge bundle of branches tied up with a string; in the Cypress all arising from a common stem which can be traced through to the top, but in the Poplar often from main branches into which the trunk breaks up, as it were, losing its individuality in proportion as these limbs assert theirs. In the Pines and Firs an important difference is expressed in the fact that from a main straight stem running through to the apex of the tree, the branches come off at nearly right angles (Fig. 1) and in radiating groups of about five or six at definite levels, that is to say, in whorls: here, then, the columnar or long-conical shape of the crown is due to the lower branches being somewhat longer than those of the next whorl above, these slightly longer than those next further up and so on to the top, a totally different arrangement from that of the Lombardy Poplar.

A pointed crown depends on the persistent up-growth of the leader, or apex of the stem, projecting somewhat beyond the branches.

But in most cases there soon comes a period when the on-growth of the leader is discontinued, either from internal causes or from accident, and the branches below tend more and more upwards and outwards, and so round off the apex, and it is the rule in Pines and Firs that after a certain height has been attained the lateral branches do this, and often in such a way that the gradually shorter and shorter branches up the tree attain

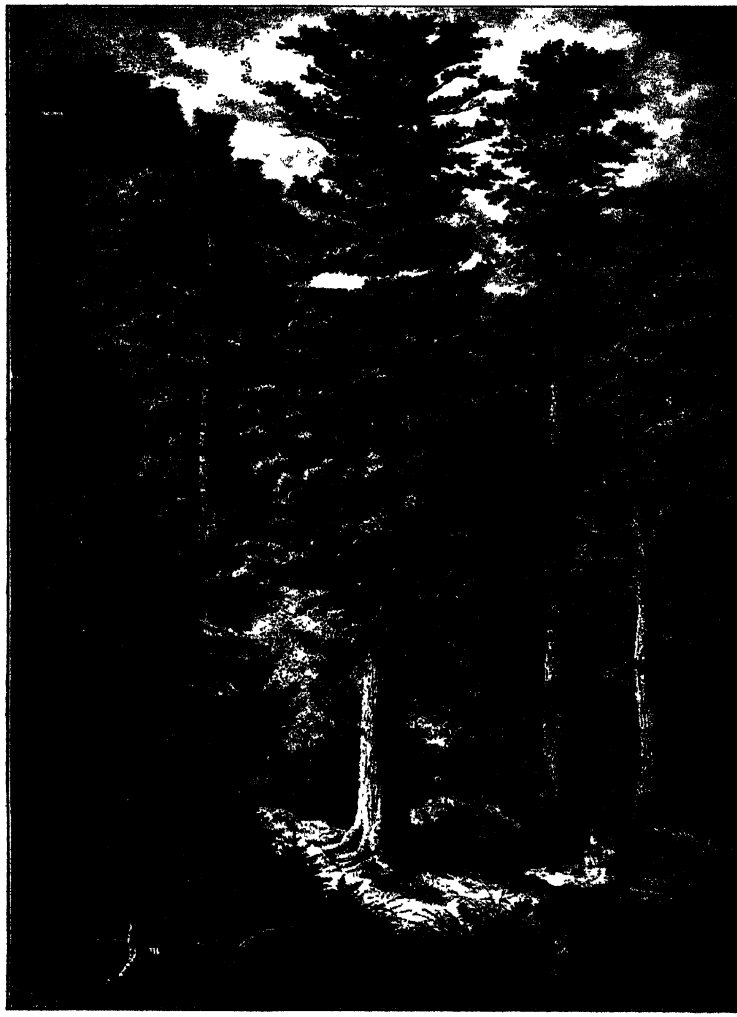


Fig. 15. *Abies pectinata*, Silver Fir (R).

an average length about equal to that of the lower ones—which also slow down their growth with age—so that what was a pointed conical crown becomes a blunt cylindroidal tree, a state of affairs often realised in the Silver Fir (Fig. 15).

Now let us suppose that a tree which has reached the condition just described begins to lose its lowermost, older branches altogether: that they die off in succession as the tip did, and are gradually removed by high winds as the dead sticks become more and more brittle, or by the various other agencies which lead to the self-pruning of trees in Nature. The first consequence may be the setting free of the lower part of the stem as a clean bole, the upper part of which still carries the upper part of the crown, the branches of which still retain their average capacity for growth and elongate more or less equally. This will result in the conversion of the previously cylindroid crown to a more or less ovoid, oblong or ellipsoidal one, a condition often seen in Scots Pine, Austrian Pine and others (Fig. 16).

But we also suppose the pointed-conical form to be preserved under similar conditions of denudation of the bole, if that process occurs before the leader has stopped growing, and if the relative growth of the branches is preserved: indeed, if the lower main branches keep up their growth vigorously, such figures as the broadly pyramidal-conic form may result and be maintained for many years.

Even further changes of shape ensue in many of the Pines, Cedars, &c. after the crown has passed through a stage such as has just been described. While the cleaning of the bole of lowermost branches proceeds, the leader ceases to grow, but the lateral branches below it continue to spread. The consequence is a more or less



Fig. 16. *Pinus sylvestris*, Scots Pine (Irv).

flattened or depressed slightly rounded head results, reminding one somewhat of a mushroom on its stalk, or even of an umbrella (Fig. 2).

Such umbellate crowns are common in old Pines, e.g. the Scots Pine, and are so characteristic of certain species that they have been termed Umbrella Pines, e.g. *Pinus Pinea* (Fig. 2).

We thus see that every possible variety of form, starting with the terete or columnar form, tapering upwards, or rounded above and more or less regularly cylindroidal, and ending with the widely spreading tabular or depressed umbrella-like head, is attainable in trees with a single main stem from which branches radiate regularly on all sides, by the mere processes of stoppage of growth of the leader, relative rapidity and continuance of growth of upper and lower laterals, and cleaning of the bole by the disappearance of the lowermost main branches as they die off in order of age from below upwards.

Of course the reader will at once see that the whole process resolves itself into a sort of natural pruning, the effects of which vary according to the disposition of the buds and twigs concerned, and the agents of which are those studied in Chapter IV.

It now remains to be seen how the equally great variety of similar forms results from such changes in trees of which the branching is—apparently at any rate—less regular and simple than in the cases cited.

If we examine a young Apple, Plane or Oak, in what nurserymen and foresters term the sapling stage, it will usually be found to present the following features. The main stem runs right through as a common axis, and terminates above as a leader, pointing vertically and keeping the prominence expressed in its name by growing forwards and giving off twigs and branches in acropetal

succession. The latter resemble those of the Pines and Firs already described in so far that they extend laterally and that the oldest and longest are below, and the youngest and shortest above; but they differ in being arranged individually at very different levels, though they come off at wide angles. The general effect is to produce the pyramidal or broad-conical form already described, but in a very different manner in detail though the attainment and maintenance of the form are similar in principle, being brought about by the relative growths of the leader and laterals (Fig. 17 I).

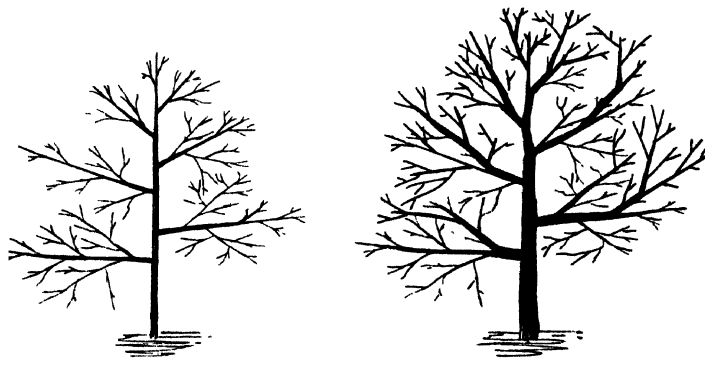


Fig. 17. Plan of development of the Apple-tree type.

On examining an older specimen of such a tree, however, we find the crown rounded off above and spreading below, evidently owing to the same causes as those already adduced for the rounding off of the Pines, &c., viz. the stoppage of growth of the leader while the lowermost laterals continue to extend as before (Fig. 17 II). But in other respects the tree is very different; the stem is no longer traceable to the top, but loses itself sooner or later in the crown, owing to the few main branches which

have persisted having developed to limbs of approximately equal value and the impossibility of deciding which of them should be regarded as the upward continuation of the axis. It is evident that many of the laterals and of their branches of the first, second and higher orders have been lost, and nevertheless the general contour of the crown as a pyramid with rounded apex, or a more or less dome-shaped structure, has been attained as perfectly

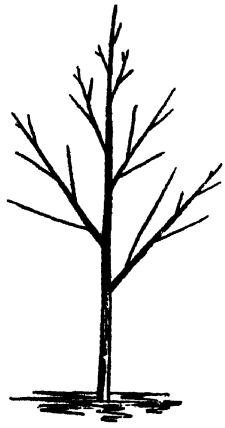


Fig. 18.

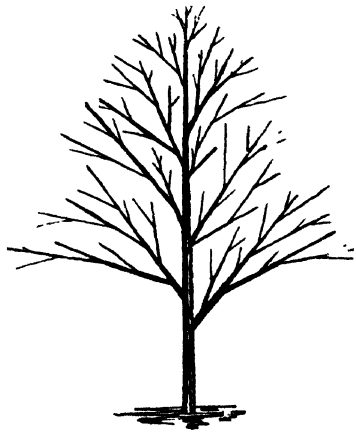


Fig. 19.

Fig. 18. First stage in development of the Lime-Willow type.
Fig. 19. Second stage in development of the Lime-Willow type.

as in the case of the Pine, where the axis runs right through and the lateral branches come off so regularly, and themselves ramify further in a symmetrical manner (cf. Figs. 22—25 and Fig. 1).

As will be seen from the more detailed analysis of the methods of branching, the dominant factor in shaping the periphery of the tree is in both cases the same, namely light; but the chief point we are at present concerned

with is the relation of the direction of the branches in the crown itself, and the changes in shape of the latter in different trees and at different ages.

Let us now examine a slightly different case. A young tree, or sapling, of the Mountain Ash, a Willow, or a

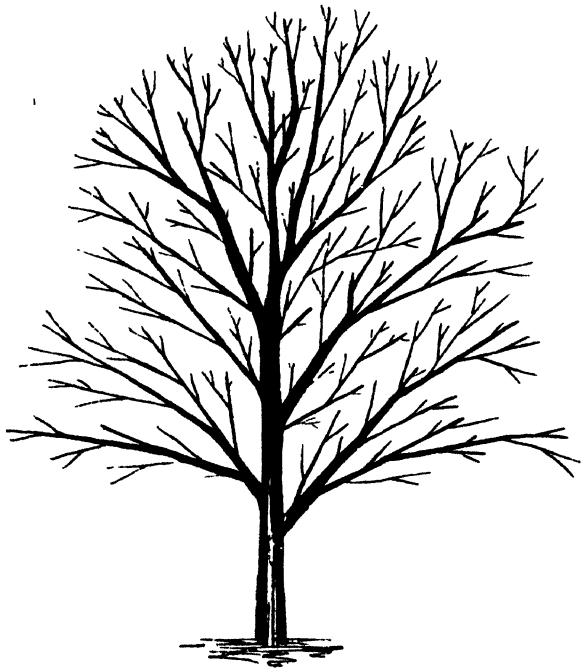


Fig. 20. Third stage in development of the Lime-Willow type.

Lime, differs from the Oak, Apple, Plane, &c. in that the lateral branches come off at a more or less acute angle with the axis, which again at this stage runs through to the top of the crown, the general shape of which is more or less that of a pointed pyramid, or a more or less

rhomboidal figure, the shape of the base depending a good deal on the persistence of the angles of the lower branches, the degree of curvature they make as they become heavier with age, and the number and lengths of the branches they give off below (Figs. 18, 19).

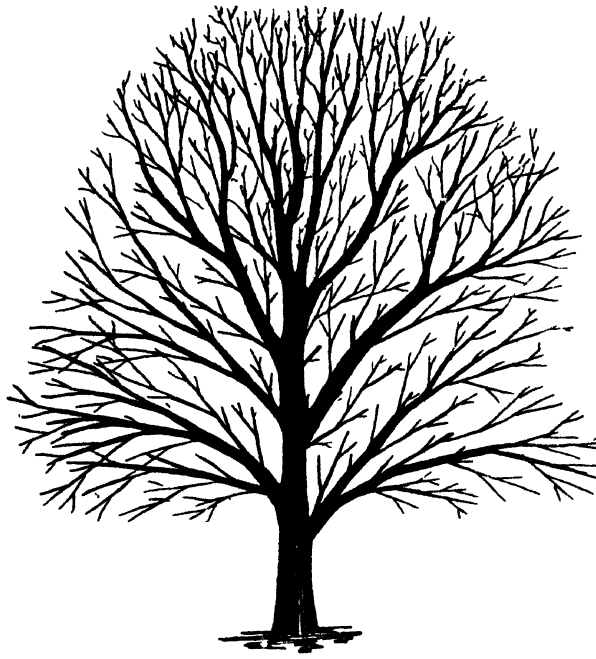


Fig. 21. Fourth stage in development of the Lime-Willow type.

Such a tree may very easily give rise to a dome-shaped crown, such as that described above, if the lower branches spread widely, or give off other branches which do so, as the leader ceases to grow, and the upper laterals gradually fill up the interspaces by their further branches

and twigs (Figs. 20, 21); or the crown may assume such forms as ovoid, oblong or ellipsoid and similar figures, with very slight differences in the details of relative elongation and ramification of the upper and lower branches.

We can make our studies of these various methods of crown-shaping by variations in the modes of branching and natural pruning more definite by reference to concrete cases treated diagrammatically.

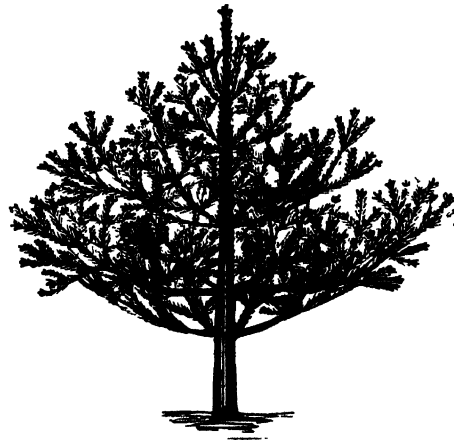


Fig. 22. Sapling of a Pine.

In Fig. 22, I have drawn a diagrammatic representation of a Pine in the sapling stage, but although only four main branches are given to each whorl we see that the rapid complexity of the branching obscures the analysis, even if each lateral only puts forth two shoots, each again bearing two shoots, and so on. In Fig. 23, a similar stage is represented in a slightly more conventional manner, the branches of each whorl which would stand

fore and aft, off the plane of the paper, being omitted, and even then the rapid increase in the regular branching of each lateral soon leads to confusion: nevertheless we see that it consists merely in each lateral bearing a pair of lateral shoots each year in succession, each of which lateral shoots then gives rise annually to another pair of laterals, each of which developes its own annual pair in turn, and so on.

Hence we know the age of such a tree at a glance, by counting the number of whorls and adding one [or more]

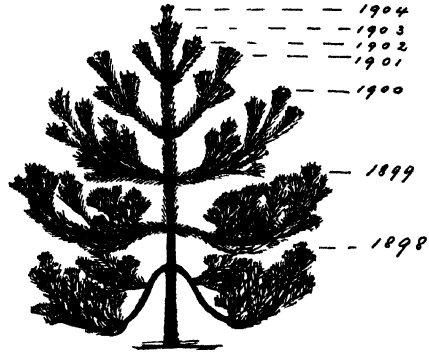


Fig. 23. Simplified diagram of a sapling-Pine.

for the seedling years in which no whorl had been developed. We also know the age of each uninjured lateral, by counting the pairs of laterals it has in its turn put forth. For instance, in Fig. 23, the fourth principal lateral counting from the top was four years previously a bud in the same condition and position as regards the then leader, as is now one of the lateral buds flanking the extreme terminal bud at the apex of the present leader; or, if we suppose the figure to represent a tree of this

spring (1904), the lateral in question was a bud in the year 1900. In 1903 it had developed into a shoot similar to one of the uppermost laterals in the diagram: in 1902 it was in the condition of one of the second laterals down the principal axis, and itself bore two subsidiary laterals: in 1901 it was in the stage now represented by the third laterals of to-day, and had grown longer and put out its own second pair of laterals, while its previous subsidiary laterals, also grown longer, bore in their turn each a pair of laterals of the second order. In 1904 it attained its present condition, and shows its four annual growths from the time (1900) when it was itself a bud.

And similarly with the principal branches lower down: the one was a bud in 1899, and shows five annual elongations, the lowermost was a bud in 1898 and shows six years' growth. The plant was a seedling in 1897 [assuming that the first pseudo-whorl arose from buds laid down the second year], and is therefore eight years old at present.

In Fig. 24 I have represented, in a similarly simplified and diagrammatic fashion, a later condition of affairs, which does not usually occur, however, until the Pine-tree is considerably older and has many more whorls than are here, for the sake of simplicity, depicted.

In the first place we note that the cleaning of the stem and older branches of the tufts of needles—each of which is a dwarf-shoot consisting of two to five green needles with a few scales (see Vol. I) and is cut off by an absciss-layer and cast normally—a process already begun in the older regions of Fig. 23, has proceeded further. Secondly we note that the stem has begun to clear itself of the older principal branches as well, the two lower whorls having already gone in the diagram, where stumps are left to mark their places. Thirdly we see that the terminal bud of the leader has stopped growing,

and the youngest laterals are already overtopping it, and themselves putting out their own laterals. And, lastly, we observe that the older lowermost principal laterals are no longer growing out so vigorously as the upper and younger ones: in other words the younger laterals are overtaking the lower and older ones in growth.

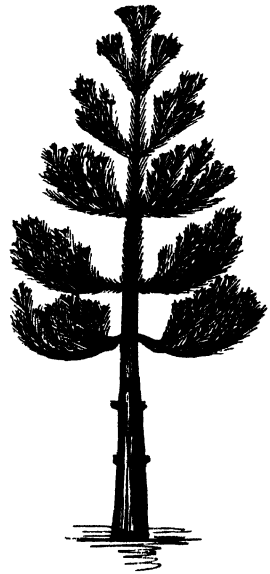


Fig. 24. Diagram of an older Pine-tree whose stem has lost its lower branches.

The consequence is the previous conical or pyramidal shape of the whole crown is rapidly changing to a cylindroid or ovoid form, and this will become more and more marked as the upper laterals tend to catch up the lower in the process of growth.

As the tree ages, the processes of change above

described will gradually alter the shape of the crown more and more until a state of affairs something like that shown in the diagrammatic Fig. 25 is attained. All further growth in height has here ceased, and the clearing of the bole of older branches has gone on until only the principal laterals of the topmost whorls are left, and these have begun to clear themselves of their older branches. The

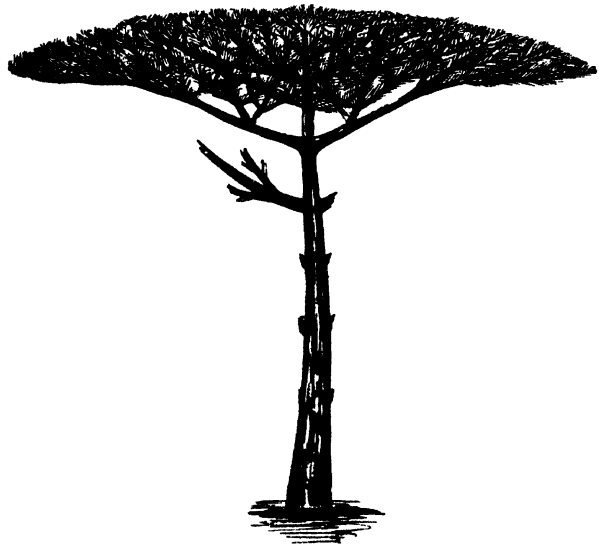


Fig. 25. Diagram of an old Pine-tree of umbrella like form.

result is a more or less rounded or flattened crown, like an umbrella on its stick, or a mushroom on its stalk, and although this condition has been reached by the repeated production of buds in regular sequence, so many incidents of competition for light and air, breakage by wind and snow, injuries by birds and insects, and so forth have occurred that the symmetry of the branching is now practically lost.

Let us now examine another case. In Fig. 26 I have diagrammatically represented the young pyramidal sapling condition of a tree with opposite and decussate buds and branches. It is obvious that if every bud developed a shoot regularly, a very symmetrical tree would result, reminding us of the example already examined in connection with Figs. 17—21.

It will also be obvious that, assuming that the above does not occur, considerable differences would result in the further branching according to whether the outwardly

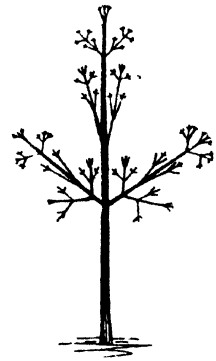


Fig. 26.

directed or the inwardly directed buds developed the more vigorously into long shoots and branches. In Fig. 27, I have represented the somewhat more vigorous growth of the outwardly directed buds, the result being a pyramidal tree of a type commonly met with among the Maples, Sycamore and others. In other respects the symmetrical development of the stem and branches has not been interfered with: the tree diagrammatically shown in Fig. 26 was photographed as it stood, and then altered

by strengthening and elongating the stem and principal branches, and throwing the energy of growth (so to speak) somewhat more into the outside secondary and tertiary laterals than into those directed inwards. This is a very common occurrence in such trees, and may be seen in medium sized specimens of Horse-chestnut, Ash, and others in many a winter landscape.

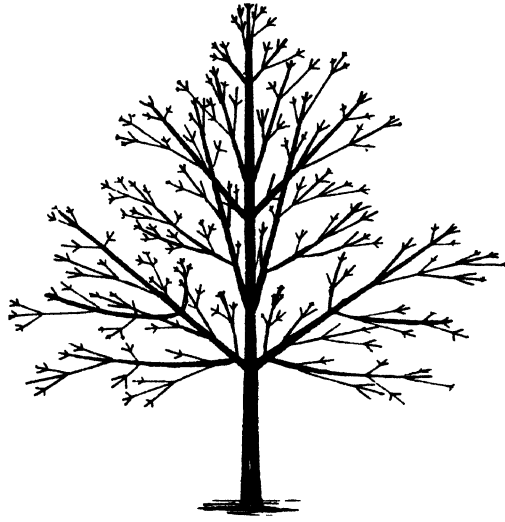


Fig. 27.

It is the continuance of this preponderance of growth of the outer laterals which leads to forms like Fig. 28, where further asymmetry is introduced by the inevitable irregularity of growth among the competing branches, for it will be noted that Fig. 28 has been developed from Fig. 27 by means exactly similar to those before employed.

But now let us see how easily the whole shape of the symmetrical crown of Fig. 26 may be altered by merely directing the energy of growth principally, but not entirely, into the inwardly directed shoots. This has been done in the diagram (Fig. 29), which is again simply Fig. 26, treated

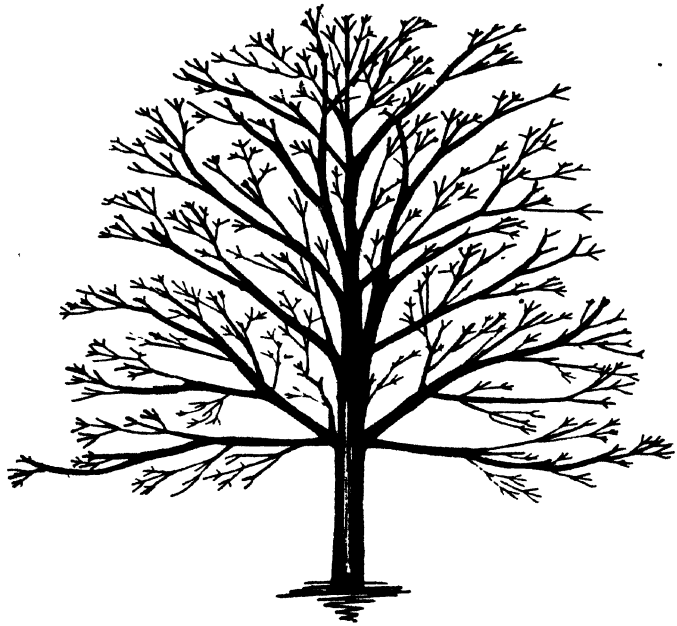


Fig. 28.

as described, the only further change introduced being the stoppage of the terminal buds of the stem and of most of the twigs at an early stage of their development, so that the tips now appear to be dichotomously branched. Not only is the whole contour of the crown altered from pyra-

midal to broadly ovoid-rounded, but it is obvious that as this tree developes the trunk will be more and more lost in the crown, and all signs of the original symmetrical tree with a principal axis running through to the top. Such a type of growth is quite common in such trees or bushes as the Lilac, Privet, &c.

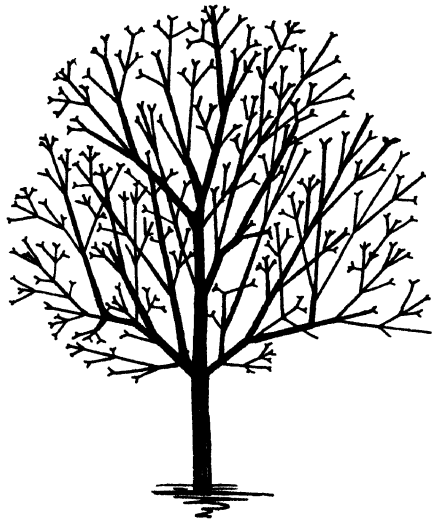


Fig. 29.

It would be easy to multiply examples of this kind of modification of the shape of the crown by slight, but increasing, throwing of the energy of growth into certain of the branches at the expense of others, in trees with decussate shoots, but the space at disposal will only permit of one more example of this type. In Fig. 30 a sapling similar to that in Fig. 26 has been represented, and its further development in Figs. 31 and 32, traced as before, but

slightly more stress laid on the downward and outward sweep with upcurving of the tips of the stronger outward

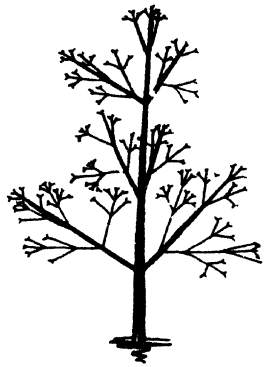


Fig. 30.

shoots in each stage, the result being a round-headed or domed tree of considerable spread, such as is often met

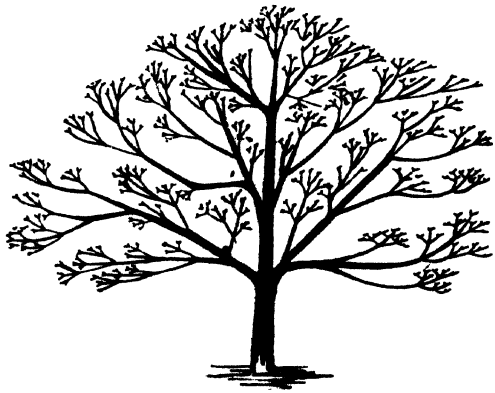


Fig. 31.

with in well-grown Horse-chestnuts developing in the open, as in a park for instance.

We will now pass to a different type altogether. Fig. 33 is a fairly representative diagram of a type of sapling abundantly represented by our common fruit-trees, the Rowan, Birch and others, and differs funda-



Fig. 32.

mentally from all the preceding in having its laterals alternately and spirally arranged on the parent axis, and coming off at acute angles from it. The simple further development of its laterals in approximately equal proportions gives us (Fig. 34) a quite common fruit-tree type and often seen in the Rowan. In Fig. 35 the only alteration

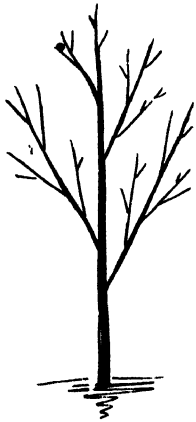


Fig. 33.

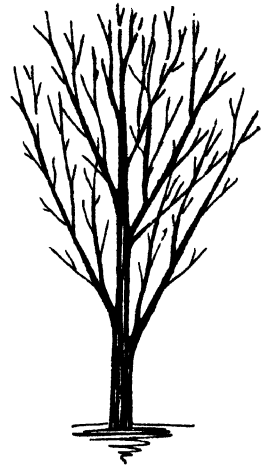


Fig. 34.

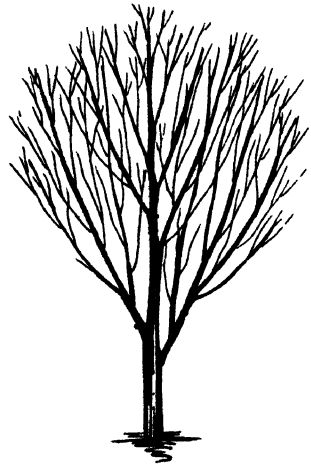


Fig. 35.

has been that of representing the principal energy of further shoot development in the two directions of greater elongation and of concentration of the shoots towards the tips of their parent axes. The type is found commonly enough in Willows and Poplars.

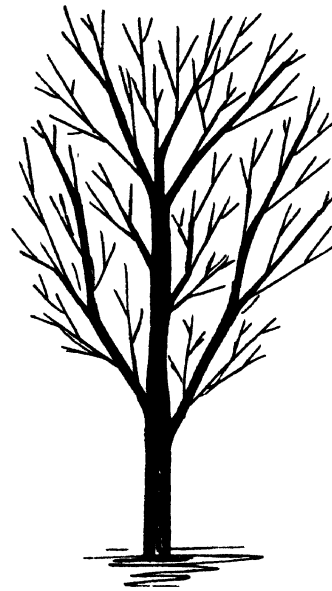


Fig. 36.

Now suppose we stop the growth in length of the principal axis in Fig. 33, and direct the energy of growth into a few only of the laterals as in Fig. 36, at the same time favouring slightly the more outwardly directed off-shoots. This rapidly leads to a form like Fig. 37, a type characteristic of the Lime, some Elms, Hazel, &c. in middle age.

A very slight alteration of Fig. 33, chiefly consisting in a tendency to an outward curvature, or an approach to a pendant condition of the tips of the branches, gives us Fig. 38, a state of affairs realised in the Wych Elm.

As a last example of this class of branch analysis, I

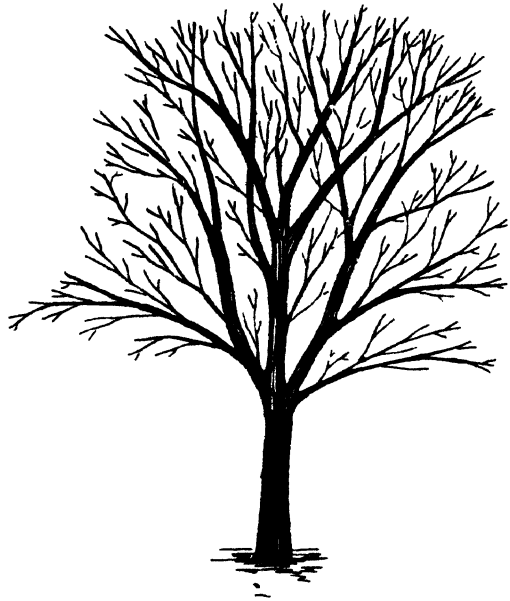


Fig. 37.

take the case of a sapling such as that in the diagram (Fig. 39). It is, as before, in the pyramidal stage common to so many young trees, and its branches are again alternate and spirally disposed; but it differs in the wide angle of divergence of the laterals on the stem. The transition to the stage figured in 40 is obvious, and such a condition is to be seen in middle-aged Planes. Here

we see the principal growth is rapidly being assumed by the lateral branches, which spread widely, while the

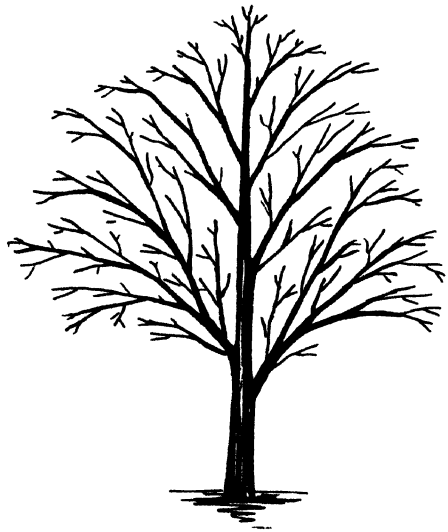


Fig. 38.

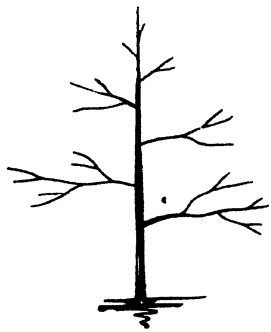


Fig. 39.

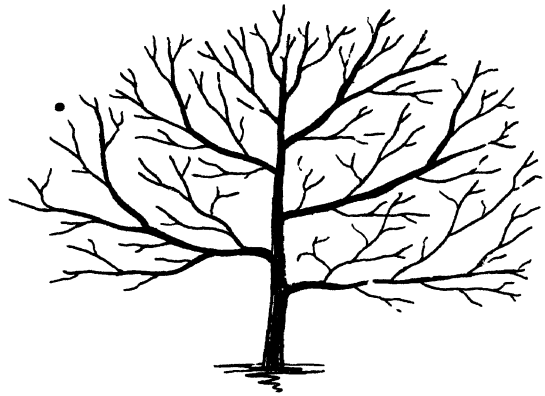


Fig. 40.

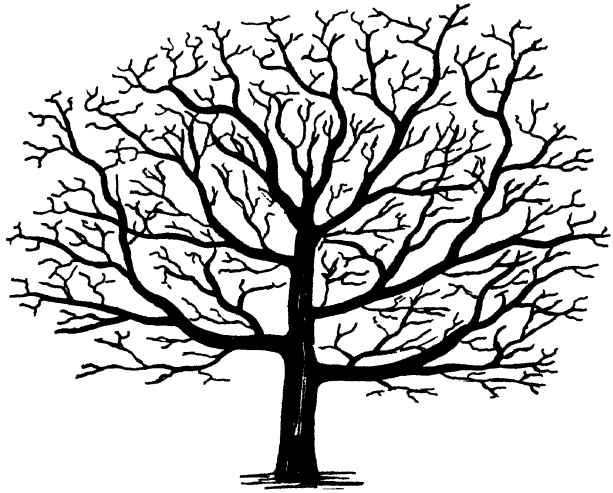


Fig. 41.

terminal shoot has ceased to elongate. The further passage to Fig. 41 is equally intelligible. Here the spreading large branches are taking on the proportions of limbs, and, owing partly to the direction of growth-energy into certain branches, at the expense of others, and partly to the abundant casting of shoots which is going on, these larger limbs and branches become very tortuous and widely extended, and an easily recognisable



Fig. 42.

type results, of which many Planes, *Robinia*, Chestnut, Walnut and Oaks would furnish examples. Such a type is shown further developed in Fig. 42.

The foregoing illustrations will suffice to show what a complex matter in its summation, but what a simple one in its graduated steps, the shaping of a tree is.

CHAPTER VII.

BARK.

Bark in *Euonymus* and Beech—Superficial periderm—Bark of the Birch—Ring-bark—Scaly bark of Plane and Sycamore—Scaly bark of Scots Pine—Fissured bark—Tow-like peeling of bark—Hardness of bark—Soft bark—Stone-bark—Protective functions of bark—Thick bark of light-demanding trees—Thin bark—Injury from sunlight and frost.

WE have seen, from our study of the shoots and twigs (Volume I), that the tegumentary system gradually undergoes changes which result, in most cases, in the replacement of the epidermis by cork, or periderm-layers, and that when these layers, which are impervious to water, develope deep down in the cortical tissues of a branch or stem, all the tissues outside the water-tight layers of cork, die off and constitute Bark.

There are, moreover, other characters of bark—using the word in this wider and looser sense—which are due to the place of origin of the periderm and the mode of its action in cutting out the true bark, as described above.

In *Euonymus*, for instance, and even in the Beech in certain cases of very old stems, the deeper cork-layers are formed irregularly, in spots as it were, in the cortex, resulting in the development of isolated scattered patches

of bark, bursting through the superficial periderm and gradually extending so as to cover the whole surface. The older of these small patches begin to flake off before the younger ones, with the result that the stem or branch obtains a peculiarly rough irregularly scaly bark.



Fig. 43. Birch (*Betula alba*): smooth bark (Irv).

More usually in the Beech, and in the Hornbeam, Hazel, *Berberis*, &c., the superficial periderms, extending regularly round the stem, gradually peel off in broad smooth ring-like lamellæ. In the Birch (Fig. 43) this is emphasized

by the peculiar constitution of the periderm, which is composed of alternating layers of thin-walled cuboidal cork-cells empty of recognisable contents, and of tougher flattened cells often filled with brown débris: although

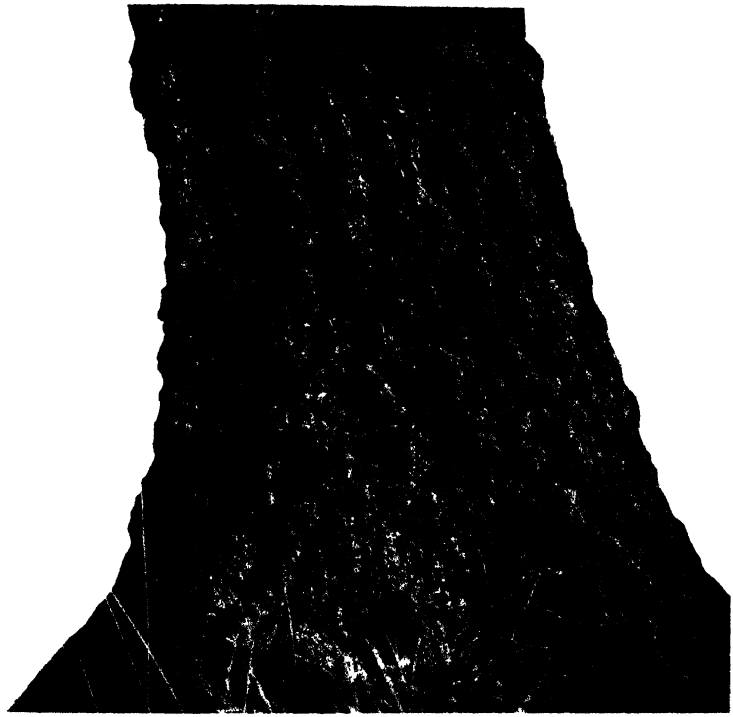


Fig. 44. Birch (*Betula alba*): rough bark and base of stem (Irv).

the whole mass is only a few millimetres thick it may flake off in thin broad ring-like papery lamellæ, often to the number of 20 or more in a year. As the stem of the Birch approaches 20 years old and upwards,

deeper cork-cambiums arise, and the lower parts may form rough, hard, deeply creviced bark, extending in old trees some ten feet or more up (Fig. 44).



Fig. 45. Plane: scaly bark (Irv).

Ring-bark, resulting from deeply situated periderms, is also formed on the Vine, Honeysuckle, *Philadelphus*, &c.

A peculiar and very characteristic form of scale-bark is produced by the true Planes (Fig. 45), and to a less marked

extent in the Sycamore (*Acer Pseudo-Platanus*). The successive periderms commence to form at various points on the stem, deep in the cortex, and their development proceeds centrifugally from each point but never extends far round the stem. The result is a thin, flattened or slightly concave, more or less circular patch of bark, and as the periderm comes to the surface at its margins this tabular patch is cut out and scales off as it dries and as the thicker branch beneath tears its edges. The denuded patches of the current runner are greenish or olive, older ones grey or brown, and they give a very characteristic appearance to the stem.

Other forms of scaly or tabular bark are furnished by the Scots Pine, Spruce, Silver Fir, Horse-chestnut, &c.

But the commonest type of bark on older stems is that known as fissured or creviced, where longitudinal cracks or clefts go deep into the substance, and the intervening parts stand up as ridges. The development of these characteristic crevices usually depends on the presence of fibrous tissues in the bark; as the addition of thickening layers to the wood beneath distends the tegumentary tissues, these fibrous masses are pulled asunder by the tangential strains, and carry with them the other tissues of which the bark is composed: then new masses are cut off beneath by the deeper periderms, to undergo the same tangential stretching and partial separation, and as the bark thus thickens the ridges are added to below and their prominence increased. Further tangential contraction of the ridges, resulting in corresponding increase of the gaping of the crevices between, is brought about by the drying up of the dead bark-tissues.

Such fissured barks are well illustrated by the Ash, *Robinia*, Norway Maple, Elm, Black Poplar, Oak (Fig. 46), &c.

In some cases, however, the predominance of fibres in the bark is so marked, that as it dries the latter shreds out into more or less thread-like or tow-like masses—e.g. *Cupressus*, *Taxus*, *Juniperus*, *Thuja*, *Bicta*, *Lonicera Xylosteum*, &c.

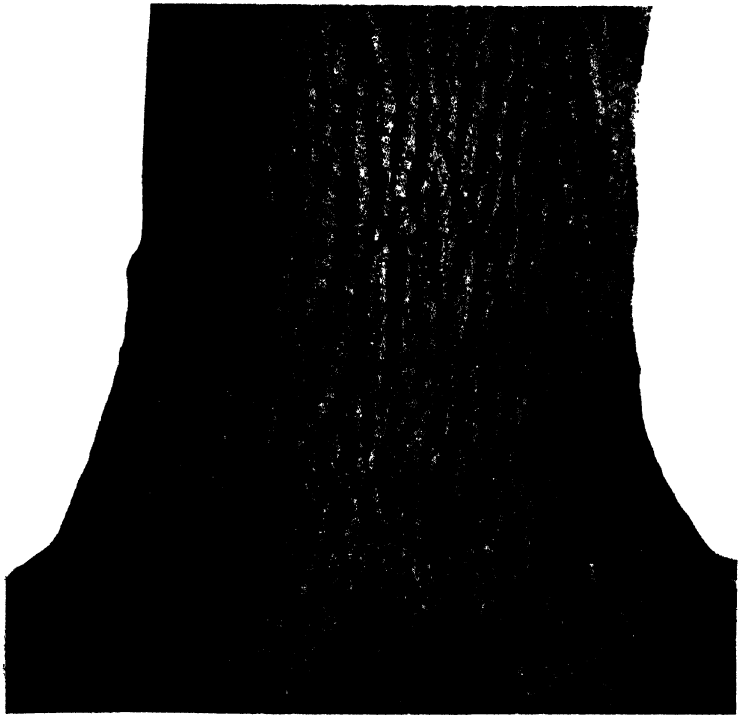


Fig. 46. British Oak (*Quercus Robur*): fissured bark (Irv).

The hardness of bark depends of course on the elements included in it. Where little or nothing beyond thin walled cork-cells are comprised, as is usual in all but old trees of

Ulmus campestris, Robinia, Euonymus, Quercus Suber, Acer campestre, Birch, Hazel, &c. the bark is easily indented with the finger nail and may be termed soft.

But in many cases the bark contains such abundance of sclerenchyma or of fibrous elements that it is distinctly hard, and when the hard elements are in excess—as e.g. in the rough bark at the base of old Birch-trees, and the rough bark which developes on some Beech-trees—it is often termed stone-bark.

The alternation of harder and softer layers is a fruitful source of exfoliation—e.g. Scots Pine, Birch, &c. These layers are not periodic in the same sense as annual rings, and they tend to form more rapidly in youth than in age.

The primary function of the tegumentary layers is no doubt that of protection from loss of water by evaporation, but one of the principal secondary functions of the tegumentary layers is to protect the living tissues within—especially the very delicate cambium—from the direct rays of the sun, and probably as much from the so-called heat rays as from the blue-violet rays so destructive to all living protoplasm.

In the case of the youngest twigs this sheltering action is supplemented by the fan-like shading afforded by the leaves, but later on the thick non-conducting periderm layers and bark may have to be relied on.

In accordance with this, it has been noticed that trees which grow in exposed situations—the so-called light-demanding trees of forest lore—have the cambium well protected by thick bark, e.g. Oak, *Robinia,* Scots Pine, Larch, &c., or, as in the case of the Birch for instance, with repeatedly laminated shells of cork of alternately thin walled air-containing cells and ordinary cork cells. It has even been suggested that the white colour, in part

due to betulin, is here effective as also in the case of *Eucalyptus*, which is also a sun-exposed genus.

Trees with thin bark, such as Beech (Fig. 47), Spruce, Hornbeam, &c., are impatient of exposure unless in clumps

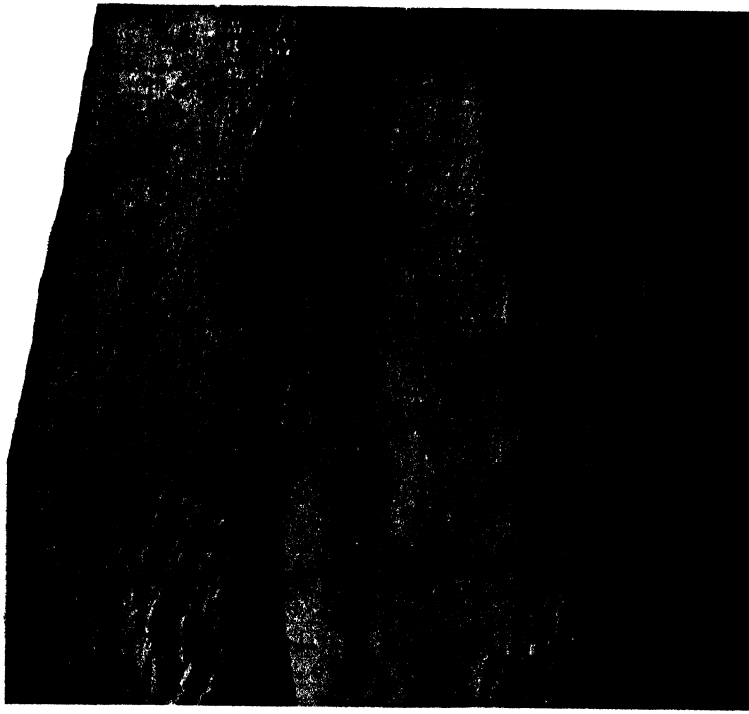


Fig. 47. Beech (*Fagus sylvatica*): thin periderm clothing the trunk (Irv).

where some mutual shading is afforded, and it is noticeable that just such shade-enduring trees suffer most if suddenly exposed, by fellings, to the solar rays, especially those from the south-west impinging on the exposed trunks are apt to produce sun scorching.

This is also true of other trees at the margins of plantations injudicially thinned—e.g. Oaks, Maples, &c.—because although such trees grown from the first in the open, are sufficiently protected in our climate, growth in dense woods is apt to induce the formation of a bark which is thinner and more succulent than the normal.

On the other hand, thin barked trees if grown exposed from the beginning in ordinary situations, are often efficiently protected by being covered from top to toe by foliage shoots, as is often seen in Beeches, Spruce, Lime, &c.

The same properties which render the non-conducting tegumentary coverings such efficient protectors against insolation, are also effective in protecting trees against the effects of spring frosts, the Birch—an especially frost-resisting tree—being a good example. It has been observed that while the younger parts of Scots Pines, Larches and Spruces, &c., on which the bark-coverings are still thin frequently suffer from frost, the older portions of the stem being better protected suffered no injury.

All these matters are important in forest-operations in deciding how gradually trees grown in close forest shall be exposed.

CHAPTER VIII.

NON-TYPICAL SHOOTS. CLIMBING PLANTS.

Elongated internodes—Methods of climbing—Ivy as a root-climber —Other root-climbers—Scrambling plants—Twining plants—Revolving movements of the stem—Direction of twining—Surface of twining stems—Torsions—Tendril-climbers—Leaves acting as tendrils—Evolution of leaf-tendrils in Leguminosæ—Stem-tendrils—The Vine—Behaviour of a tendril—After-effects on grasping tendrils—Adhesion-discs on tendrils—Climbing methods of species of *Bignonia*—Outgrowths on tendrils—Tendril-like roots—Anastomosis of climbing roots—Hook-climbers—Branch-climbers—Watch-spring-like tendrils—Tendrils in Vitaceæ.

WE have seen that the typical shoot is an erect structure consisting of stem and branches bearing leaves and flowers and appendages of that kind. There are very many cases, however, where the shoot, though manifestly typical in its essential nature, departs sufficiently from the normal to be remarkable at once. Striking examples are found among the numerous kinds of climbing plants.

In the typical erect shoot, the principal function—the exposure of the leaves to plenty of light and air—is brought about by the primary axis being sufficiently stiff and strong to support the weights of leaves, flowers and fruits, in spite of the winds which tend to throw the whole structure; and we have seen several varieties, from

the short-stemmed rosette-plants to the woody tree, palm or bamboo, which may easily be referred to the type, but differ according to the length, strength, and duration of the internodes, and the amount of branching they undergo.

In climbing plants, however, the additional fact comes in that a support is needed for the shoot. The latter may be quite typical as regards its parts, but the elongated internodes are not stout nor rigid enough to stand alone and bear the weight of the foliage; and in accordance with this fact these plants make use of other solid objects—other plants, rocks, &c.—to climb up. The well-known fact that all these climbing plants begin life with typical, self-supporting, erect shoots suggests that the feebleness of the elongated internodes of so many of them is the derived character consequent on the acquirement of the climbing habit, and as there is [dubious] experimental evidence to show that additional strains in stems bring about the construction of mechanical tissues, we may probably look on the climbing shoot as having sacrificed strength of internodes, which has become unnecessary, to length, which is an advantage where it leads to the exposure of the foliage high up above the thicket which would otherwise dominate it. In a certain sense indeed the weak elongated internodes of many climbers remind us of the feeble drawn stems of plants which have grown in too scanty a light, though I would not advise the student to speculate upon any causal connection between the two cases, but simply note that as with a long and slender climbing plant so with a lanky "drawn" plant the extra length of stem gained by the elongation of the internodes increases the plant's chances of rising above the surrounding plants and other objects and exposing its leaves to the light and air.

Climbing is accomplished in several ways, but the principles in play are of two kinds. Either the shoot-axis itself is the active agent in obtaining the support required, as in a Bramble which scrambles over a hedge, or a Hop which twines up a pole; or the shoot-axis is, on the whole, passively supported by appendages which cling to the wall, trunk, twigs, or other objects up which the climbing is effected, as in the Ivy clinging by roots (Fig. 48), or the Pea or Vine (Fig. 49) which climb by means of tendrils. Indeed the above gives an outline scheme for treating the subject, for although a few plants employ simultaneously two or more of the above means, most adopt one only.

With regard to plants which climb by means of anchoring rootlets, the Ivy is a good example to begin with.

Its young shoots, at first erect and independent, apply themselves close to the wall, or similar support, owing to negative heliotropism, and put out short rootlets at first from the neighbourhood of the nodes, and later along the internodes, on the side of the stem which is next the wall and therefore darkest and most sheltered. These rootlets fit their surfaces closely into the roughnesses of the wall, crevices and so forth, and glue themselves there by the softening of their cells.

Some species of Figs (e.g. *Ficus repens*) can cling by similar roots even to the glass of a greenhouse, where Darwin observed them exude a sticky fluid, which soon cemented them tightly to the glass.

Piper flumense, *Tecoma radicans*, several species of *Cereus*, *Marcgravia*, and various Aroideæ also climb by means of anchoring roots like the Ivy. Other cases are *Ercilla*, the stem of which creeps up a wall and is anchored there by adhesive discs which are roots, and

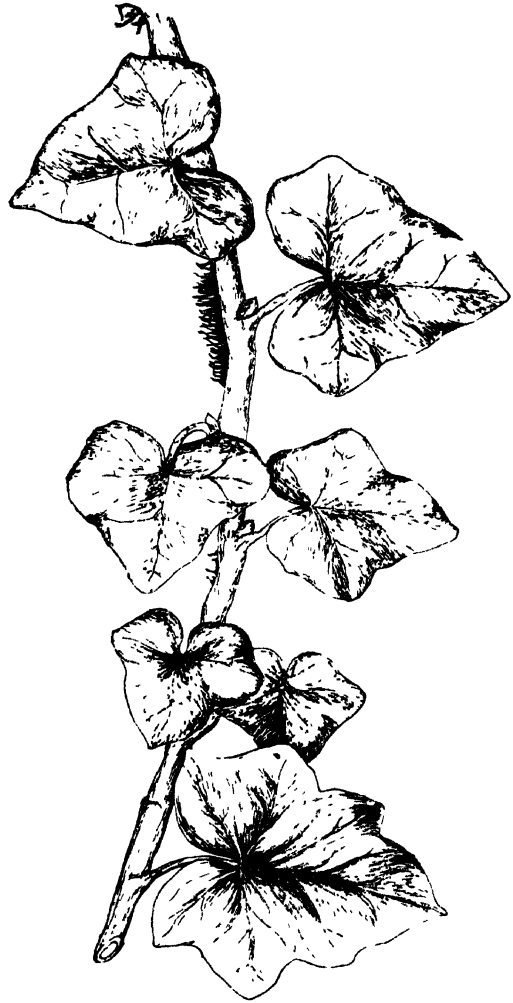


Fig. 48. Ivy, *Hedera Helix*, a climbing shoot (D).

Derris bantamensis, where the adventitious rootlets form spiny outgrowths which aid in climbing.

What may be termed scrambling plants offer suggestive examples of such as are, so to speak, learning to climb. The young shoots of the wild Rose, Bramble and especially the Rattans (the climbing Palm or *Calamus*) are at first quite independent, but as they push their way through or over the surface of hedges or other thickets, the recurved prickles on their stems, which present no obstacle to forward growth, offer so many points of more or less definite hold-fast on the interlacing branches and twigs against which the shoot leans, that it is impossible for the long stems to fall. This is well demonstrated by trying to pull such a shoot out of a hedge by the cut lower end. In the Rattans the recurved harpoons are in part leaflets.

Similar hold-fasts are afforded by the much smaller and more numerous asperities on the shoots of the Cleavers (*Galium*), or by the out-spread or recurved leaves or branches, thorns, &c. of numerous other thicket and hedge-plants, such as species of *Geranium*, *Asparagus*, Barberries, *Lycium*, &c. which weave themselves through the tangled masses of twigs or scramble over them in various ways.

Still more efficient are the recurved persistent petioles of certain Combretaceæ, Jasmineæ, &c., which remain as hooks after the leaf has fallen. Certain Bamboos are held up by their long, hard reflexed buds.

In twining plants we find more special adaptations to the habit of using other plants or parts of plants as a support.

As in previous cases the young shoots emerge from the soil as erect and self-supporting structures, but the terminal portion, of two or more young internodes and

the bud at the end is observed to become more and more curved, as if nodding under the weight of the bud. In addition to this, this curved or arched upper stretch is seen to be acting in a very peculiar manner. The plane of the arch lies at a given moment, say, north and south, so that the bud points to the north; but if we examine it some time afterwards, say half an hour to several hours, the bud will be found directed towards the east or towards the west, and after a similar period towards the next point of the compass—the south—and so on. In other words, the bud is being directed to every point of the compass in succession, either passing round in the direction of the hands of a watch or the reverse.

But since the internodes do not stop their elongation during this circumnutation[1], as the circulating nodding is called, it follows that the real direction in space of the bud describes an ascending spiral.

Since the internodes and bud do not revolve around the axis of the pith, and since the convex side of the arch is longer than the concave side, we see that the circumnutation is due to the growth at any moment being most rapid along the vertical line which crests the convex side, and least so along the line parallel to this on the concave side: this causes the nodding. The moving round is due to this longitudinal line of quickest growth slowly passing round the stem, either from left to right or conversely.

As the arched shoot gets longer and describes bigger sweeps, it usually comes at last in contact with a vertical support, and then its free swing is stopped. But another event now comes into play. While growth as a whole—i.e. the elongation of the internodes—still goes on, that

[1] [This phenomenon in twining plants is, by some botanists, regarded as not being of the nature of circumnutation.]

side of the climbing shoot which touches the support is so acted upon by the contact that it grows still more slowly than the outer free convex side, and the stem now twines round the vertical stick or other support, the at first loose and flat coils becoming steeper and tighter later on, as the then older parts try to erect themselves more and more.

Most twiners coil in the direction opposite to that of the hands of a watch—e.g. *Convolvulus*, Kidney Bean, *Pharbitis*, *Akebia*, *Wistaria*, *Ipomœa*, *Aristolochia*, *Asparagus*, &c.

Nevertheless there are many which invariably twine in the opposite direction—e.g. the Hop, Honeysuckle, *Jasminum*, *Polygonum*, *Plumbago*, *Clerodendron*, *Thunbergia*, *Tamus*, *Lapageria*, &c.

While nothing is known of the importance or meaning of the direction of the coiling, it is interesting to note Darwin's observations that several plants, e.g. *Loasa aurantiaca*, *Scyphanthus elegans*, and the occasional twiner *Solanum Dulcamara*, coil in both directions alternately, i.e. the direction of twining is reversed after a few turns in any one direction. The same occurs in *Blumenbachia*, *Hibbertia*, *Testudinaria sylvatica*, *Ipomœa jucunda*, and some others.

Many twining stems are quite smooth, e g. some species of *Convolvulus*, *Bowiea*, *Tamus*, &c., but others have hairs (*Hoya*, *Buttneria*), bristles (*Iodes ovalis*, *Tetracera*), or reversed barbs (*Polygonum*, *Capparis Roxburghii*, *Ipomœa muricata*), or hooks of various kinds (Hop), these and the ridges sometimes found are possibly of service in giving a firmer hold. These ridges must not be confounded with the twistings or torsions which climbing stems undergo *after* coiling round the support. The torsions are produced partly by the friction on the support as the coils

tend to straighten, as may be illustrated by coiling a piece of elastic round a pencil, and then pulling the upper end of the elastic and steepening the coils, and partly by internal actions which are not understood but whose effects are comparable to those in the twisted stems of erect plants. These latter are well seen in the Hop and Convolvulus, where they extend right up to the end of the young internodes, and are formed before the tightening up of the coils begins.

It is very questionable whether any real insight into the causes of the twining are to be got from what we know so far as to the geotropism of these shoots. The facts are these.

If a pot-plant of a climber such as the Hop is allowed to slowly rotate on the klinostat, the already twined youngest parts unwind themselves from the vertical support, and straighten themselves vertically. This and other experiments have led to the assumption that the young growing internodes are geotropic not in the usual sense, where they would grow more rapidly either on the lower side (apogeotropic) or the under side (geotropic), but so that one *side* grows more quickly than the other, and so drives the nutating portion across the line of the vertical (lateral geotropism) and moves it in the plane of the horizon. This brings it about that the plant can only twine round a vertical or nearly vertical support, as is found to be the case with all twiners. As the young twining internodes get older, but before growth has ceased in them, they become more and more apogeotropic, and so erect themselves more and more, thus tightening the coils as they become steeper.

In view of the demonstrated irritability of the twining stems of *Cuscuta*, a parasitic convolvulaceous plant which sends haustoria into the host-plant on which it twines, it

has been sought to show that twining plants are all more or less irritable; however this may be, it is at least clear that the irritability of ordinary twining shoots is of a far lower order than in the case of the true tendrils to which we now turn.

The highest adaptations for climbing are met with in tendril-climbers, not only because they develope special organs, the tendrils, for grasping supports, but also on account of the extraordinarily beautiful irritable phenomena displayed by these organs.

The simplest form of tendril climbing is shown by plants like the Garden Nasturtiums (*Tropœolum*) where the long petiole of an ordinary leaf coils itself once or twice round a stick or twig, and so obtains a hold-fast. Similarly with *Maurandia*, *Solanum*, *Convolvulus* and *Antirrhinum cirrhosum*. In *Fumaria*, *Clematis* and *Atragene* the same coiling propensity is observed in the petiolules of the leaflets; while in other cases—*Nepenthes*, *Gloriosa*, *Flagellaria*, *Mutisia*, and some *Fritillarias*—it is the rachis or prolonged midrib which coils.

In the remarkable case of the climbing Ferns *Lygodium*, the twining is effected by the entire rachis, which goes on growing for several seasons, and it is difficult to decide whether this should be regarded as a tendril-climber or as a twining-plant.

As we advance through the numerous forms known the tendril is found to become more and more a special organ, which in its most highly developed condition is thin, long and filamentous in shape, and so distinctly irritable that even a few strokes with a pencil, or at most a few minutes contact with a stick, suffice to so irritate the touched side that it grows more slowly than the side not touched. The consequence is that the tendril coils round the stick or other solid object.

In the cases hitherto cited the tendrils are only incompletely differentiated: one sees at a glance they are leaf-stalks or prolongations of midribs, &c., and in *Smilax* the two long thin tendrils flanking the base of the leaf-stalk are stipules.

But the best idea of the evolution of these leaf-tendrils is obtained by comparing a series of Leguminous plants—*Vicia, Pisum, Lathyrus,* &c.—where almost every stage can be traced between cases of pinnate leaves with three or more pairs of normal leaflets, beyond which the rachis is produced as a tendril bearing one, two or more pairs of tendrils in place of leaflets, e.g. *Vicia sativa, Pisum sativum,* and cases where, as in *Lathyrus Aphaca,* all the leaflets have disappeared and the rachis alone persists, transformed into a long slender tendril bearing two large stipules below.

We have only to suppose the stipules to disappear also, and the place of the leaf is taken by a simple tendril only, a case realised in some Bignoniaceæ, Cucurbitaceæ, *Cobœa scandens* (Polemoniaceæ) and *Mutisia* (Compositæ).

So far the tendrils considered are all more or less obviously leaves, or parts of leaves, as to their morphological nature; but it is a very common occurrence to find true tendrils in such positions, or bearing such structures (leaves, flowers, &c.) as to warrant our concluding that they are altered branches in origin. One of the best studied examples here is that of the common Grape Vine (Fig. 49), or that of the Virginia Creeper (Fig. 50), where, partly from their position opposite the leaves, and partly from the fact that small scale-leaves are borne on them with branches in their axils, their branch characters are clearly recognisable: taking the internode below the tendril, and tracing it up to the latter, we have the tendril terminating this segment of the shoot, and the next internode above may be regarded

as having developed from a bud in the axil of the leaf. Thus the stem is made up of segments of different orders, each tendril marking the termination of the lower segment: the whole shoot is, in fact, a sympodium.



Fig. 49. Vine, *Vitis vinifera* (Sc).

It is, however, by no means always easy to prove whether a tendril is a modified branch or a leaf, and I regard it as of too little importance to the subject to enter into the many hypothetical discussions as to the morphology of the tendrils of certain plants, such as many

Cucurbitaceæ, Passifloraceæ, Sapindaceæ, &c., although for examples of studies in morphology—where the nature of an organ is determined from the place and manner of its development, with full reference to other organs—few parts offer better exercise to the advanced student.

Apart from the easily determined leaf-bearing tendrils referred to above, those of many Passion Flowers, and such Sapindaceæ as *Cardiospermum*, *Serjania* and *Paullinia*, are regarded as modified branches, and in some cases can be shown to be so because they bear flower buds, so that their peculiar positions at the side of a leaf, or even below it, must be explained in accordance with the fact that it is by no means necessary that branches should spring from the axils of leaves: indeed there are plenty of well-known examples to prove this also.

Whatever the morphological nature of the tendril may be, its essential characters are distinctly adaptations to the climbing habit, and in the highly specialised typical tendrils we find long, thin, irritable filaments which are not only carried up by the growth movements of the young shoot which bears them, but which themselves also nutate in small circles of their own, so that they exert a sort of groping movement, and at once coil round any thin support they come in contact with, and this may be inclined at any angle.

Once the end of a tendril is fixed, the coiling does not cease, but extends down the free length, with one or several reversals of direction, and so slings the shoot-axis on a spiral spring.

The after-effects of the continued contact on the coiled tendril are often shown in increased thickening, and the formation of wood-tissue, so that the stem remains anchored by thick curved woody hooks, as in *Solanum jasminoides* where the petioles are used, *Uncaria* (*Nauclea*)

where the peduncle hooks over a branch; in both cases the hook retains its hold, long after the leaf or inflorescence has dropped off. Similar hook-tendrils are formed by peduncles or branches in *Ancistrocladus*, *Artabotrys*, *Luvunga*, *Olax*, *Hugonia*, and *Strychnos*.

Still more remarkable are the after-effects of the continued contact stimulus at the tips of the tendrils of many species of *Ampelopsis*, *Vitis*, and *Bignonia*, which attach themselves to rocks, walls or the rough bark of trees. The phenomenon can be readily observed in the Virginian Creeper (Fig. 50). The delicate tips of the tendrils swell into fleshy discs, which fit and glue themselves into the interstices of the support, and remain attached for long after the season of their formation, the rest of the tendril throwing itself into woody, elastic, spring-like contractions or coils.

The climbing of many *Bignoniæ* is effected by triple hooks, like bird's claws, which are the three reduced terminal leaflets of one of the pinnate leaves. These hooks are curved and sharp pointed and cling to rough surfaces: they and the tendril they terminate are sensitive to contact. In some of these *Bignoniæ* delicate adherent roots are also formed from the same node which bears these tendrils, and since the tendrils coil round a stick and the claws hook over the tendril when thus brought round, we get very complex adaptations brought into play.

Nor is this all, for, as Darwin showed, some species of *Bignonia* (e.g. *B. Tweedyana*) combine with the above the power of twining also, whence we may have four methods of climbing—twining, root-climbing, tendril and hook-climbing—going on simultaneously in one and the same plant. Tendrils are normally quite smooth, but cases occur where stiff hairs—*Iodes*, *Serjania*, *Paullinia*—or even recurved hooks—species of *Desmodium*, *Acacia*, *Cæsalpinia*

—are found on them: in such cases the imperfect irritability suggests that these are not fully specialised as tendrils proper. Roots are employed as tendrils by some

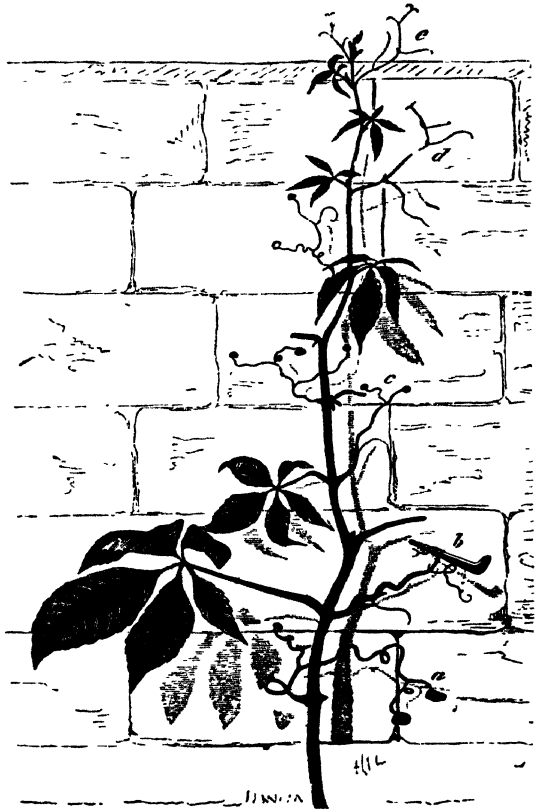


Fig. 50. Shoot of *Ampelopsis*, Virginian Creeper, climbing by means of branch-tendrils, some of which twine round nails, &c. (*b*), others fasten their tips to the bricks by means of sucker-like dilations (*a* and *c*); *d* and *e*=young tendrils (Sa).

plants, e.g. some *Lycopodium*, *Dissochæta* and *Vanilla*, where they are capable of twining round thin supports. But the commonest mode of using roots as climbing organs is, apart from the cases mentioned, where aërial roots are thrown round branches or trunks, to which they affix themselves by the whole surface, and form complex networks owing to the anastomoses between roots crossing in different directions—e.g. many epiphytal Figs in the Tropics.

Among the most remarkable tendrils are those furnished by the branches (*Strychnos*, *Olax*, *Ancistrocladus*, *Artabotrys*), peduncles (*Uncaria*) or petioles (*Luvunga*) of some tropical plants, which are sensitive to contact, if continued, and then curl over and become thick and woody, gripping the object as persistent hooks after the rest of the branch, peduncle or leaf has fallen. Slender branches, not essentially altered, are often found to make irregular twists round other branches, and so play the part of tendrils—e.g. species of *Securidaca* (Polygoneæ), Hippocrateaceæ, Connaraceæ, *Dalbergia variabilis* and other Leguminosæ; and a comparison of these and the curious, stiff, watch-spring-like hook-tendrils of some Rhamnaceæ, *Bauhiniæ*, and Sapindaceæ, afford evidence for the evolution of the irritable branch-tendrils (inflorescences) of Vitaceæ, Passifloraceæ, *Antigonum*, *Petermannia cirrhosa*, *Erythropalum scandens*, *Iodes*, and certain Apocynaceæ.

In Vitaceæ we meet with simple coiled tendrils (e.g. Vine), tendrils the tips of which form adhesive discs after contact (*Ampelopsis quinquefolia*); and tendrils which have such discs from the first as in species of *Cissus*, so that the evolution of branch-tendrils seems to have followed similar lines here to those followed by the leaf-tendrils of the Bignoniaceæ.

CHAPTER IX.

NON-TYPICAL SHOOTS.

Creeping shoots—Super-terranean types—Subterranean types—Rhizomes—Monopodial rhizomes—Bracken and others—Ascending rhizome of Primrose—Sympodial rhizomes—Thick rhizomes as food reservoirs—Thin rhizomes; stolons or soboles—Subterranean stem-tubers—Potato—Other tubers—*Arum*—Corms of *Crocus*, *Colchicum*, *Cyclamen*, and *Ranunculus bulbosus*—Bulbs—Pseudo-bulbs of epiphytic orchids—Shoots in aquatic plants—Rhizomes—Stolons—Submerged shoots with or without floating leaves—*Lemna*-type—Types of *Pistia*, *Aldrovandia*, and *Salvinia*—Succulent plants—Succulent stems in Cactaceæ, *Euphorbia* and *Stapelia*—Succulent leaves.

A SECOND class of non-typical shoots are characterised by their habit of creeping away from the centre formed by the parent plant or root, and pushing their terminal buds some distance in a radial direction from the already occupied and exhausted area from which they started. This they may do simply along the surface of the ground, as in the case of the *runners* of the Strawberry, *Ranunculus repens*, *Hieracium Pilosella*, Ground Ivy, &c., or beneath the surface as in the *Rhizomes* of *Carex*, Yellow Flag, *Equisetum*, Bracken Fern, &c. The creeping Willow, *Salix repens*, does either or both.

In both sets of cases the object attained is to develope

new tufts of leaves, or to throw up new stems in comparatively unoccupied ground, and most plants which put out these travelling shoots prove themselves advantageously endowed by the facility with which they spread themselves rapidly over large areas and even dispossess others already in occupation of the soil. This is well exemplified by the garden Hawkweeds which rapidly infest a whole bed by means of their creeping stolons above ground, or by species of *Equisetum* which will do the same thing by means of their underground rhizomes.

Taking the super-terranean shoots first, their nature is always easy to understand, because they have definite nodes and internodes and develope ordinary leaves from the former, and often, as is well seen in the runners of the Strawberry, put out roots from the nodes which enter the soil direct.

Differences are observable in these creeping shoots according as they are annual or perennial, and primary or accessory structures. Thus, in the creeping Willows, of which our *Salix repens* is a common example, and of which many species exist in high latitudes, the prostrate stems are perennial and woody and are the only ones formed by the plant, remaining for years connected to the original centre; many *Potentillæ* and Labiate plants behave similarly. In other cases the older parts behind die off after a year or more, as in many Clovers, the Periwinkle, the creeping *Lysimachiæ* (*L. Nummularia*, *L. nemorum*) and many Saxifrages and Hawkweeds. In these cases the lengthening internodes drive the terminal parts forward year by year, and these root, while the hinder parts perish, so that each year the current plant is developed further and further away from the parent centre, and becomes independent by the dying off of the hinder parts of the creeping shoots.

In the Strawberry, and some Saxifrages (e.g. *S. sarmentosa*, *S. flagellaris*, &c.) and Houseleeks, the older nodes, separated by long or short internodes of the creeping shoots developed from the axils of leaves, do not produce leaves, or produce only rudimentary scales, and the terminal bud becomes anchored by roots to the ground, while the thin connecting *runner* dies off sooner or later. In some Houseleeks indeed the terminal bud breaks away from its short runner as an independent structure: it is clear that here we have a case where no difference in principle exists between the *bulbil* and this terminal *bud* of the runner—suppress the latter, and the separated axillary bud is a bulbil.

Where annual plants send out prostrate shoots—e.g. species of *Anagallis*, *Polygonum*, *Veronica*, &c., they die away at the close of the vegetative period and do not serve to spread the plant: such shoots are merely described as *prostrate*, or *procumbent*, and if their terminal portions curve upwards into more or less erect shoots they are termed *ascending* (e.g. *Ranunculus repens*, many species of *Veronica* and grasses).

In some works on descriptive botany distinctive names are given to special cases of the above creeping shoots, e.g. *trailing*, *procumbent*, or *prostrate*, when they lie loose along the ground but do not root at the internodes (Periwinkle, Knotgrass); *repent* or *creeping*, when the prostrate shoot roots at the internodes, and dies off behind (Couch-grass, Mint); the *stolon*, *sarmentum*, or *runner*, has very long and slender internodes, and some of the nodes not rooting and with scale-leaves only (Strawberry); while the short stolons of Houseleeks, *Lobelia cardinalis*, &c., with their detachable terminal rosettes are termed *offsets*. But it is not found easy in practice to maintain the distinctions in all cases, for many trailing shoots will form roots at the

nodes in damp situations or in wet seasons, while offsets frequently strike root before separating, or before their connecting stolon dies away.

Rhizomes are subterranean creeping stems, and their own leaves, the presence of which at once distinguishes them from roots, are small and not green, excepting in cases where (e.g. Bracken Fern) they are first elevated above ground into the light by the upgrowth of long leaf-stalks.

While the definition of the rhizome is easily applied in most cases, it must not be forgotten that many perennial super-terranean stems which creep close to the ground may gradually sink in partly by the drag exerted on them by their roots and partly by the rising of the surface of the soil as time goes on—e.g. some creeping Willows. Moreover some plants, such as the Potato and Mint, throw out both underground and super-terranean creeping shoots, apparently according to the level of insertion of the leaves from the axils of which they spring; while the thick rhizomes of the common garden Iris (*I. germanica*) are as often on the surface of the ground as below. These remarks will suffice to show that no essential difference in principle exists between the two classes of creeping stems —subterranean and super-terranean.

The rhizome of the common Bracken Fern grows horizontally some 6—8 inches below the surface of the ground, and throws up one leaf each year from a point about 2 inches or so behind the tips, which is growing slowly forwards. If we take a rhizome at least four or five years old, and dig it up when the current year's leaf is fully expanded above ground in the summer, there will be found a younger leaf, still underground and not expanded, about half-way between the tip and the expanded leaf: this leaf will come up into the air

next spring. Further forwards, and close beside the extreme tip of the rhizome is a still younger leaf in the form of a mere hump: this will be the expanded leaf of two years hence. Behind the expanded leaf of the present year, are the remnants of those of previous years. From the under surface of the rhizome the true roots are given off. We thus have a rhizome which grows onwards at its tip, and throws out leaves in succession from its older hinder parts: in other words a rhizome with indefinite or

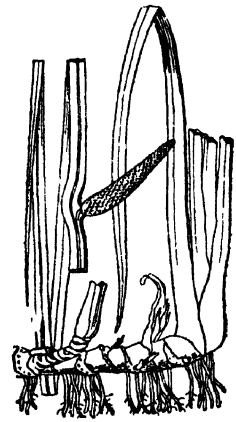


Fig. 51. *Acorus Calamus*, Sweet Flag, ½ nat. size, showing rhizome (B and T).

unlimited growth of its apex—a monopodium. In *Oxalis Acetosella*, the Wood-sorrel, Herb Paris, the same occurs, except that in each season several scale-leaves are formed, and two or three foliage-leaves and flowers are developed from the axil of one of these. The short ascending rhizome of the Primrose behaves similarly: each year a tuft of radical leaves is developed, bearing flowers in their axils, while the true end of the rhizome remains as a bud in the

centre. In this and other cases where the internodes are very short and the bud comes nearly vertical from the soil the rhizome is often termed a root-stock: other examples are *Trillium*, *Cicuta*, *Scabiosa*, *Polygonum Bistorta*, and some Water-lilies, &c.

In sharp contrast to these monopodial rhizomes are those which, like the Solomon's Seal, *Iris*, Bamboo, Sweet Flag (*Acorus*, Fig. 51), Ginger, &c., where the apical bud grows forward for a time, forming scale-leaves and roots, and then turns upwards to develope its apex as the current year's shoot. After the vegetative period this shoot dies down, and a lateral bud from the axil of one of the subterranean scale-leaves grows forward as the segment for the next year, and will in its turn send its apical portion up into the air next season, to die back in turn, and be succeeded by another axillary bud, and so on. In these cases the growth of the rhizome is definite or limited, and an old specimen really consists of series of segments, each of which was the branch for its vegetative season: it is a sympodium.

In the cases given, and in very many others such as *Asparagus*, *Polygonum cuspidatum*, *Lunaria rediviva*, *Sparganium*, *Butomus*, *Convallaria*; Tway-blade, *Corallorrhiza* and other orchids, &c., the rhizomes are more or less thickened and fleshy, and often have their outer walls evidently protected by strengthening layers. These facts are in accordance with their office as storage-reservoirs. The leaves above ground make far more organic food-materials during the period of their exposure to the light and air, than is necessary for their present needs: the surplus is deposited as starch or in other forms in the underground rhizomes, and it is at the expense of these stored materials that the new segment developes next year and grows sufficiently to send up and expose a new

set of green leaves. It is also for this reason that one hacks in vain at the rhizomes of such weeds as *Ægopodium podagraria*, Colt's-foot, *Polygonum cuspidatum*, *Harpalium*, Twitch, or *Equisetum*, in the hope of exterminating them: each severed piece merely forms a new bud from the axil of a scale-leaf, and this at the expense of the stored food-materials grows up as a new plant.

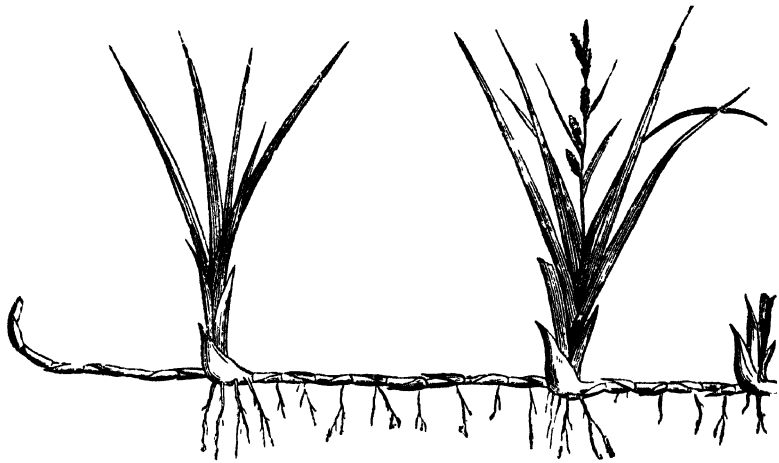


Fig. 52. Rhizome of a sedge (Le M and D).

These facts help us to understand how it is that in some rhizomes the parts behind soon die off, the reserve materials being only stored in the younger forward regions, and these latter thus become isolated in the soil at a distance from the parent centre at a very early date—the only distinction, because all rhizomes die off behind sooner or later.

It is customary to distinguish thin creeping rhizomes with long internodes as underground *stolons* or *soboles*—

e.g. Couch-grass and the slender creeping rhizomes of *Carex arenaria* and *Psamma arenaria*, the sand-binding Sedge and Grass so much used in reclaiming land on the sea-coast.

The student will see that just as with creeping stems above ground, so with rhizomes below, every stage is to be met with between annual and perennial outgrowths which remain attached all their lives to the parent centre, to such as become very early detached as independent terminal (or axillary) buds with a store of reserve materials, and the understanding of this facilitates our comprehension of the next category of underground shoots, viz. *Stem-tubers*.

In the Potato-plant, it only requires little more than casual observation to see that each tuber (potato) is attached by its posterior end to an underground stolon springing from the axil of one of the lower leaves, and that any assumed resemblance of this stolon to a root results from lack of attention; for although it is thin, long, cylindrical, and devoid of green colour, it is also provided with nodes and scale-leaves along its course, and ends in the tuber. More careful observation of a Potato-plant dug up in July shows that the tuber is nothing but a swollen bud, with scale-leaves of its own: as it grows bigger during the period towards the end of summer when the small potatoes are being filled with starchy materials from the leaves, these small leaves and the minute buds in their axils become driven further and further apart on the enlarging periphery of the tuber, as the stores of reserves swell the stem of the bud: it is these minute scales and their still smaller axillary buds which are popularly termed the "eyes" of the potato. These points are made out even more clearly on "seed-potatoes" in spring, because the buds ("eyes") are then beginning to sprout.

Stem-tubers of the same kind are found in the South American plant *Ullercus tuberosus*, a member of quite a different family, the Jerusalem Artichoke, *Stachys tubifera*, &c., but in the last two cases the swollen bud composing the tuber is not on a long stolon. These cases, and their relationships, become very clear on comparing the short, swollen, scale-bearing underground runners of *Smithiantha zebrina*, and the similar super-terrestrial ones of *Kohleria digitaliflora* and other Gesneraceæ, with the tubers of *Stachys tubifera* and the potato. In *Apios tuberosa*, a North American leguminous plant, several but not all of the internodes of the stolon swell to tubers, in *Vitis gongylodes* only one or two, each of which, therefore, is devoid of "eyes" on its sides: in *Nelumbium luteum* one internode only of a short stolon thus swells, and has only a terminal bud. In the Black Bryony (*Tamus communis*) and other Dioscoreæ, the lowermost internode above the cotyledon swells as a tuber about the level of the soil; and in *Testudinaria* this grows larger year by year until it attains enormous dimensions, throwing up new stems annually from its terminal buds. In *Bowiea* we have also a perennial basal corm. In the cases last mentioned, where the tuber consists of swollen parts of the *main* axis, we have the key to an understanding of several peculiar modifications of stems. It is clear that such tubers are distinguishable by no sharp lines from the short erect rhizomes called "root-stocks," and in some Gesneraceæ (e.g. *Corytholoma splendens*) the whole rhizome becomes a large irregular tuber, and similarly in many Basellaceæ. The next example will show that these cases are equally closely related to what are termed *Corms*.

The common Arum has a very short, horizontal swollen rhizome (root-stock) which ends in the bud that developes

the leaves and flowers of this year; just behind this ascending terminal bud, is found a smaller one—the bud for next year—developed from the axil of a scale-leaf.

If with this we compare the corm of a Crocus, the resemblances are obvious. The corm is, in fact, a short, swollen stem-base, with a series of scale-leaves surrounding a bud, at its apex, and bearing roots below. Buds may also arise from the axils of the scale-leaves, and so the corm may have more than one on its upper surface.

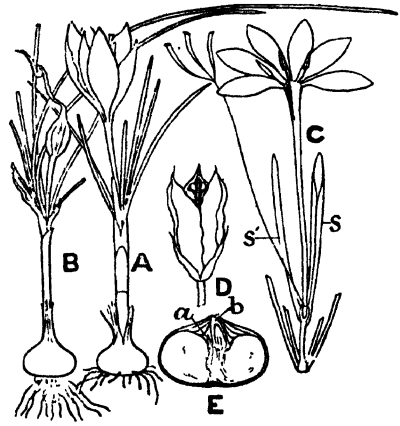


Fig. 53. *Crocus*. A. *Crocus sativus* in flower; B. Same in fruit; ¼ nat. size. C. Flower dissected showing lower (*s*) and upper (*s'*) membranous spathes; the style has been removed from the perianth-tube. D. Fruit beginning to split, ½ nat. size. E. Corm of *C. vernus* cut lengthwise, ½ nat. size; *a*, base of last year's shoot; *b*, bud of shoot which will develop on germination (Maw).

But the scale-leaves, and the buds in their axils, need not arise high up on the tuberous stem of the corm; but may spring from its sides, or even near its base—e.g. *Colchicum*, *Eranthis*, &c. In *Colchicum* in fact we have one internode only, the lowest, swelling up as the reservoir

of reserve materials and surrounded by sheathing scale-leaves, and similarly in *Cyclamen*: from an axillary bud of one of these the flowering stems and green leaves of the current season arise, and are fed by the contents of the corm. Then the green leaves send down supplies to swell the basal part of this bud into a new corm, an axillary bud on which will form the leaves, &c., for next year; and so on. In *Crocus*, on the other hand, and in *Gladiolus*, the swollen part of the corm consists of *several* basal internodes, and the axillary buds whose swollen bases will form the new corms often appear on the top, owing to the accident of high insertion of the leaves whose axils are concerned. In some *Crocus*-corms, however, the new buds (future corms) appear at the sides, or even the base, in each case from the axil of a scale with a corresponding insertion.

The tuberous swelling at the base of the stem of *Ranunculus bulbosus* also concerns several internodes, and is a corm in the same sense as in *Bowiea*, *Testudinaria*, &c.

If, now, the reserves of food-material whose storage brings about the swelling of the short *stem* in a corm like that of *Crocus*, were deposited instead in the *leaves* or *leaf-bases* inserted on this stem, which would then be only short and not swollen, we should term the structure a *Bulb*, and this is the only essential difference between these two sets of organs. Some authors, indeed, apply the term solid bulb to corms like *Colchicum* and *Gladiolus*, which are invested by sheathing scale-leaves, to mark the distinction from naked corms like *Cyclamen* where the insertions of the scale-leaves stop near the apex; but little is gained thereby as the corms of *Crocus* and others show.

As the Bulb proper has been dealt with in the section on buds no more need be said in this connection. In many epiphytic tropical orchids, however, the base of the

shoot embracing one or several internodes becomes tuberous and stored with water and reserve materials, as do the fused sheathing bases of the leaves, the laminæ of which



Fig. 54. *Bulbophyllum barbigerum*, Sympodial orchid showing pseudo-bulbs (Veitch).

fall: these "solid bulbs" are usually termed *pseudo-bulbs*. A striking example is that of one species of orchid with pseudo-bulbs a yard or more long and as thick as the

wrist, and marked with the scales of several dozens of leaves.

The foregoing are prominent types of modified shoots growing under or near the ground, and concern land-plants especially. But similar modifications occur in aquatic plants whose roots are in the soil, while the shoots are wholly or for the most part in water.

Thus, species of *Sparganium*, *Zostera*, *Acorus*, *Potamogeton*, *Typha*, various Water-lilies, *Myriophyllum*, *Marsilea*, &c., afford examples of rhizomes; while *Ranunculus aquatilis* and *R. hederaceus*, *Hottonia*, *Limnanthemum*, *Mentha aquatica*, *Alisma*, *Hydrocharis*, *Poa aquatica* and *P. fluitans* generally have stolon-like branches which creep on the surface of the mud and emit roots into it.

Many aquatic plants, however, have the majority of their leafy shoots either wholly submerged and buoyed up in the water, as *Utricularia*, *Myriophyllum*, *Elodea*, &c., or with some at least of the leaves floating on the surface, as some *Potamogetons*, *Ranunculus hederaceus*, *Hydrocharis*, &c.

In *Lemna*, the Duckweed, the whole shoot of the leafless plant is represented by the floating discoid green bodies so well known on ponds and ditches, from the centre of which, below, the single root hangs vertically down into the water. Species of *Pistia* and *Pontederia* also float free on the water, their leaves emerging into the air, while *Aldrovandia*, some *Utricularieæ* and others only bring their free leafy shoots just to the surface. In the cases of *Salvinia* and *Azolla* we have floating horizontal shoots, creeping on the surface of the water as it were.

Of all modified shoots the strangest is probably the swollen fleshy form acquired by certain desert plants, or by such as are at certain seasons of the year exposed periodically to excessive droughts.

The best known are the leafless Cacti of Central America and Northern South America, and the Cactus-like Euphorbiæ of S. Africa and Asia, and the whole of their organisation is adapted for the storage of water in the tissues of the stem, and its safe-keeping and economy.

It is, so to speak, an accident merely that these shoots present such stumpy and curious shapes, because this is a consequence of the reduction of their surfaces to minimise transpiration; and since this is brought about by the suppression of their leaves, it entails a corresponding diminution of their capacity for decomposing carbon dioxide, and therefore of growing rapidly. Species of *Stapelia*, South African Asclepiadeæ, have similar swollen Cactus-like shoots.

The fleshy Cacti show all stages of reduction from the leafy *Pereskia*, with thorns in the leaf-axils, and *Opuntia*, with flattened fleshy stems still bearing temporary leaves, to forms with flattened, or cylindrical, pyriform, globoid and variously grooved stems entirely devoid of leaves, but abundantly protected by thorns of the most varied shapes—straight spines, hooks, &c.

In all such cases the hard cuticular covering and reduced transpiring surface, the abundant stores of water in the juicy fleshy internal tissues, and the protected stomata in the furrows, are in accordance with the conditions of extreme drought in the arid regions occupied by these plants. They are adapted to existence in hot desert climates, and to this end expose as little surface as possible for evaporation; and since they can also only expose a small surface for assimilation, their growth is very slow. Since they store relatively large quantities of water, however, it is of advantage to them to be protected by the formidable armatures referred to against the marauding animals which would otherwise soon exterminate them.

Many other plants of arid regions meet similar conditions of existence by having more or less succulent internodes or stems, and transient, small or no leaves, e.g. species of *Senecio*, *Sarcocaulon*, *Salicornia*.

But in many cases, such as *Aloë*, *Agave*, Crassulaceæ, *Gasteria*, &c., the succulence is transferred to the leaves, which become correspondingly stout and fleshy, and have thick cuticles and few or protected stomata, while the axis undergoes no essential modification. In a certain sense, and bearing in mind the super-terranean habit and that the chief point in succulent shoots is the storage of water, we may compare Cactiform stems with tubers, and these Crassuloid forms with bulbs.

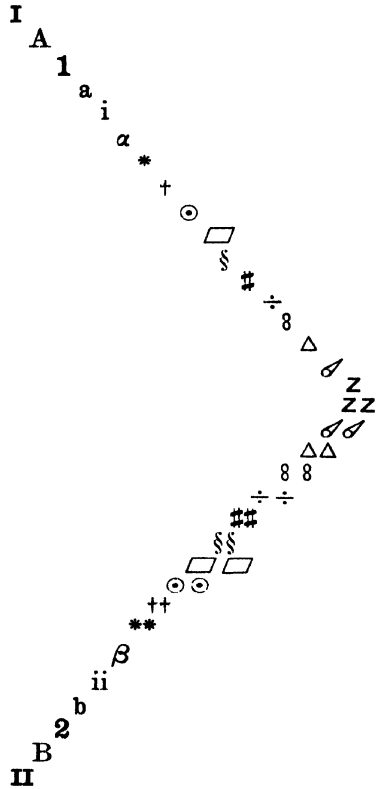
All transitions occur from shoots with long internodes and merely succulent leaves otherwise little altered—e.g. *Inula crithmoides*, *Crithmum maritimum*, *Cotyledon umbilicus*, *Sedum Telephium*, species of *Senecio*, &c.—to forms with short internodes and extremely fleshy leaves, reduced in surface to cylindrical or other simple shapes, and forming closely crowded rosettes, as in many species of *Crassula*, *Sedum*, *Mesembryanthemum*, Portulacaceæ, *Aloë*, *Haworthia*, *Gasteria*, *Agave*, *Fourcroya*, &c.

[Spiny and thorny shoots, also green assimilating stems, including cladodes, have been discussed in Vols. I. and II.]

PART II.

SPECIAL.

In order to facilitate the running down of species in the following classification, the signs in the accompanying list are used in sequence and indented as below:—



CLASSIFICATION OF TREES AND SHRUBS ACCORDING TO THEIR SHAPES.

I. TREES.—I.E. THERE IS ONE CONSPICUOUS STEM, OR TRUNK, BEARING THE HEAD, OR CROWN, OF FOLIAGE. [For (II) see p. 219]

A. WEEPING—i.e. MOST OF THE SMALLER BRANCHES AND TWIGS LONG AND PENDULOUS; OLD BARK FISSURED; FOLIAGE LIGHT AND DROOPING, DECIDUOUS; LEAVES LANCEOLATE GREYISH-GREEN; FLOWERS IN CATKINS, SEEDS MINUTE COMOSE.

Salix babylonica, L. Weeping Willow (Fig. 5). A tree of Central Asia, often planted near water, 25—30 feet high at most, and easily recognised by its long and slender sweeping pendulous twigs, grey (sometimes red-brown) fissured bark and catkins.

Relatively few other trees with weeping habit are common, but varieties of Ash, Birch, Larch, Elm, Spruce, &c., usually denoted var. *pendula*, &c., occur. They are at once distinguished by several characters common to the normal species (which see).

B. NOT WEEPING.

[The ends of the twigs may bend over, and even be slightly pendent, but they are not long, thin and pendulous as a whole.]

(1) Crown fastigiate—i.e. the branches and twigs are erect and stiff, giving the whole tree a very narrow besom-like appearance.

(a) Old bark dark brown, deeply and widely fissured and rugged; foliage bright green, of broad trembling deciduous leaves, on numerous thin twiggy upright shoots; catkins pendulous, seeds minute comose.

Populus nigra, v. *pyramidalis*, Desf. (Fig. 4). Up to 100 feet high and often planted in groves, forming a conspicuous feature in the landscape since the masses of foliage are dark. The female trees are not often seen. It is a mere variety of the Black Poplar (see p. 213).

Fastigiate varieties of a few other deciduous trees occur, e.g. Oak.

(b) Bark reddish-brown, stem channelled; but the best characteristic is the dark evergreen foliage, of small densely crowded scale-like leaves. Cones rounded and short, of few quadrangular scales. Seeds with slight border.

Cupressus sempervirens, L. Roman Cypress (Fig. 55). About 60—70 feet high, very dark and close foliage. A fastigiate variety occasionally planted. Easily distinguished from the Poplar by the evergreen foliage, cones, &c.

There are other fastigiate forms of Conifers—e.g. *Cupressus funebris, C. Lawsoniana, Taxus*, &c. occasionally seen.

(2) Crown not fastigiate nor weeping.

[For (b) see p. 136.]

(a) Crown expanded and depressed, forming an umbrella-like or mushroom-like head on the elongated stem. Foliage tufted at the ends of the radiating branches, of acicular leaves in pairs.

(i) Bark thick and reddish-grey, deeply fissured, and stem knotty. Needles long



Fig. 55. *Cupressus sempervirens*, Roman Cypress (F).

(125—150 mm.) and reddish-brown; cones about 100 mm. Seeds almost wingless.

Pinus Pinea, L. Stone Pine (Figs. 56, 58). Attaining 60—80 feet, but rarely seen over 30—40 feet. Foliage dense and dark.

(ii) Bark orange or sienna and cast in large scales in upper parts of stem, but more rugged fissured and greyish below. Needles not over 40—70 mm., and cones pointed, dull grey, 50—70 mm. long; seeds winged.

Pinus sylvestris, L. Scots Pine. This only refers to very old trees in favourable situations. Young Pines are conical or cylindroid-conic in form, and clothed from base to apex, or nearly so, with the branches in pseudo-whorls (see p. 75).

Other Pines in old age may assume the umbellate form above described, of which *P. Laricio*, considerably like *P. sylvestris* but with darker and longer foliage and bark nearly black, and *P. Pinaster*, somewhat resembling *P. Pinea*, with dull grey bark tinged with reddish-violet, and cones in clusters, are most likely to be met with.

Old trees of *Pinus Strobus*, *P. Tæda*, &c. tend to form a somewhat dome-shaped crown on a longer or shorter stem, nearly approximating to the umbrella-type; and the same is true of some other trees—e.g. *Quercus Suber*.

(b) Crown not depressed nor umbellate on a tall stem.

(i) Crown elongated and obviously longer than broad.

[For (ii) compare (⊙⊙) on p. 205.]

[For (β) see p. 163.]

(*a*) *Crown at least* 3—4 *times as tall as wide—i.e. more or less cylindroid, or long oval, pointed or blunt in outline.*



Fig. 56. *Pinus Pinea*, Stone Pine (F).

[For (**) see p. 155.]

Crown tapering to a point, owing to the prolongation of the stem through it as a leader. Foliage clothing the stem from base to apex, or nearly so. General shape cylindroid-conic, ovoid-conic, or narrow pyramidal. Upper branches shorter than the lower.

(Terms like 'pyramidal-pointed,' 'pointed-conical,' 'ovoid-acute,' 'spiriform,' and 'tapering' also apply, but the shapes are not sufficiently definite and constant to be classified further.)

[For (††) see p. 148.]

† Branches in pseudo-whorls—i.e. inserted at definite intervals at the same, or nearly the same, levels round the stem—and radiating thence. Upper branches shorter than lower. All are Conifers.

[For (⊙⊙) see p. 144.]

⊙ *Branches sweeping forwards, and up-turned at the ends, which bear tassel-like masses of long needles in tufts of* 2—5.

▱ *Needles* 2 *in each tuft; cones ovoid—more or less pointed.*

§ *Needles short and stiff,* 50—60 *mm. long. Cones dull brown, about* 40—50 *mm. long.*

Pinus sylvestris, L. Scots Pine (Figs. 7, 16). Any height up to 80 feet or more, but not usually of the narrow pyramidal form after 30 feet or so (see p. 67). The upper branches are obliquely ascending and green; the lower, horizontal or curving down and then upturned at the ends, which are tufted and sweep forwards and often upwards, with orange-red periderm. Young foliage bluish-glaucous. Bark orange-sienna-brown, scaling.

Pinus montana, usually of rambling shrubby habit, is sometimes similarly pyramidal, and is distinguished by its browner bark, shining cones and other details.

§§ *Needles* 100—200 *mm. or so long, and cones over* 50—100 *mm. long.*

‡ *Sombre tree with deep green foliage and dark coarse bark. Needles* 100—150 *mm. long, and cones* 50—70 *mm. long, shining yellowish or pallid brown.*

Pinus Laricio, Poir. var. *austriaca.* Black Pine. Not always easily distinguished from the Scots Pine unless the bark and cones are well developed; but the rigid needles are coarser, longer, and of a duller darker hue. Crown often ovoid-pyramidal.

‡‡ *Cones shining, at least* 100 *mm. long; needles* 120—200 *mm. long, and bright green.*

÷ *Cones in clusters, oblique tawny.*

Pinus Pinaster, Soland. Cluster Pine (Fig. 57).

÷÷ *Cones not clustered, chestnut-brown.*

Pinus Pinea, L. Stone Pine (Figs. 56, 58). It is not easy to distinguish *P. Pinea* and *P. Pinaster* when young and pyramidal. Both have reddish-grey fissured bark. The larger cones and longer leaves at once mark them off from *P. sylvestris* and *P. Laricio* var. *austriaca*; the polished cones also from the former which has, moreover, more scaly and orange-sienna bark: the colour of cones and bark also from *P. Laricio* var. *austriaca.*

▱▱ *Needles more than* 2 *in each tuft.*

§ *Cones erect or outstanding, ovoid, and not over* 150—200 *mm. long, with slight prickles; leaves* 3 *in the tuft, bright green.*

Pinus Tæda, L. Loblolly Pine. An American tree reaching 80—100 feet, with delicate grass-green foliage, and reddish-brown bark with flat ridges and fissures. It

rarely attains anything like the above height in England, and tends to extend early.

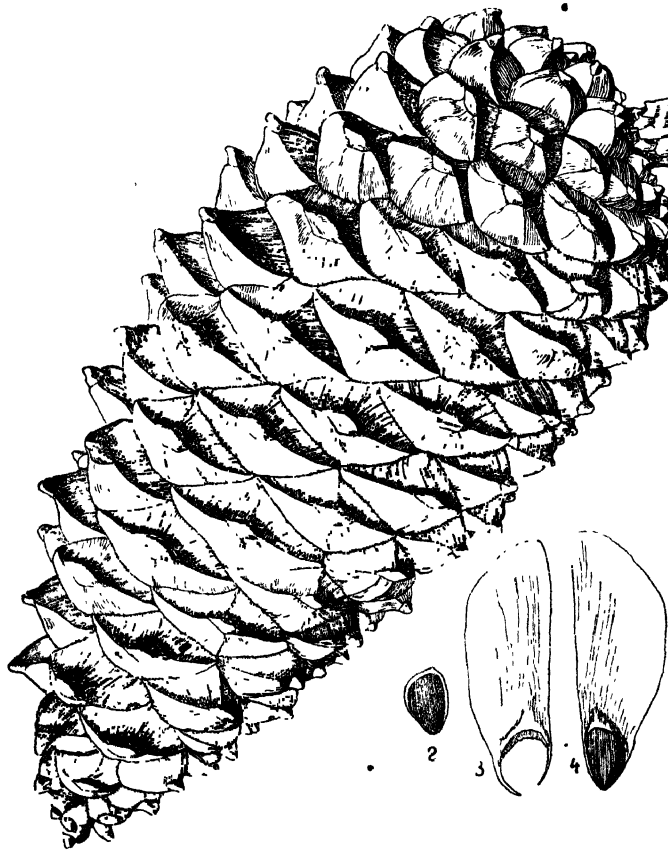


Fig. 57. *Pinus Pinaster*, Cluster Pine. 1, ripe cone; 2, seed deprived of its wing, seen from above; 3, wing of seed seen from below; 4, winged seed, seen from above. (All natural size, after von Tubeuf.)

A few other 3-needled Pines—all from North America—occur in cultivation, some with immense cones and long leaves, each over 300 mm. in length, e.g. *P. Coulteri*.

§§ *Cones not prickly, rather thin scaled, and hardly or not at all pointed. Needles 5 in the tuft, 100—200 mm. long.*

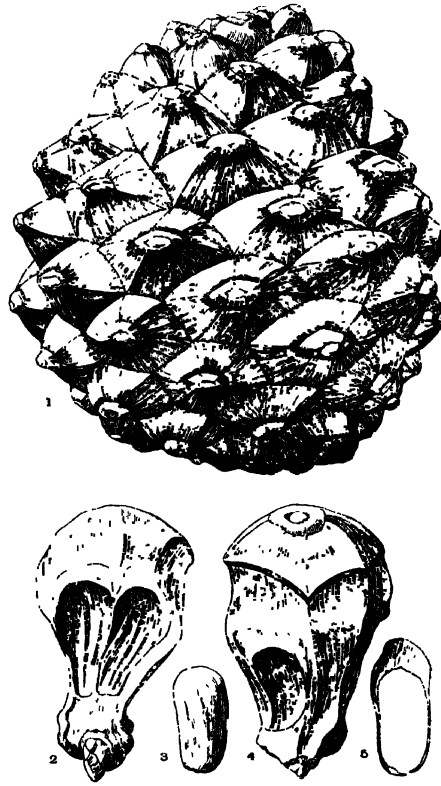


Fig. 58. *Pinus Pinea*, L. 1, ripe closed cone; 2, cone-scale viewed from above; 3, mature seed; 4, cone-scale viewed from below; 5, detached wing of seed. (All reduced, after von Tubeuf.)

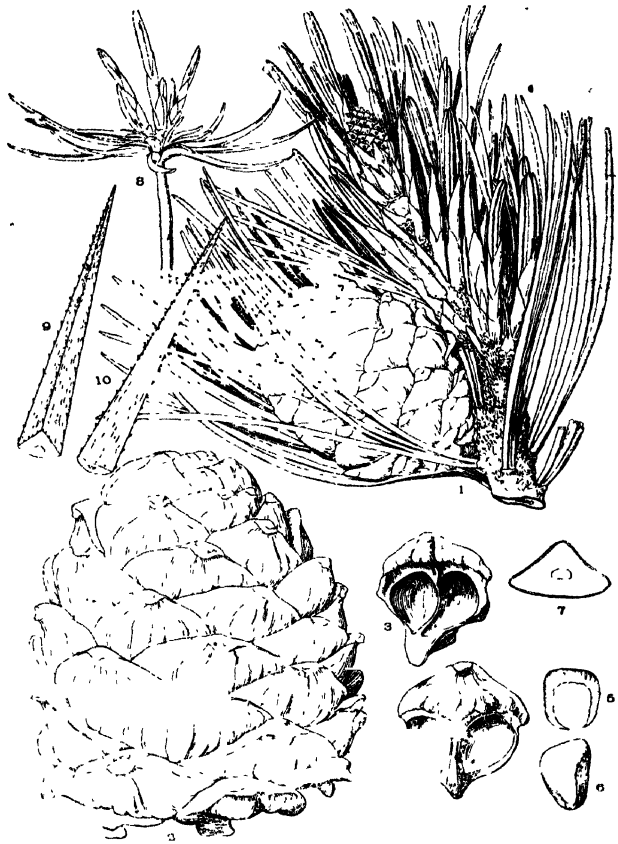


Fig. 59. *Pinus Cembra*, L. 1, shoot with young and one-year-old cones, in summer; 2, ripe cone in its second autumn; 3, cone-scale viewed from above; 4, cone-scale viewed from below; 5, detached wing of seed; 6, seed; 7, transverse section of leaf; 8, seedling in its second spring, showing cotyledons and primary leaves; 9, tip of cotyledon viewed from above; 10, tip of primary leaf viewed from above. (All reduced, after von Tubeuf.)

‡ *Cones ellipsoid, erect,* 50—80 *mm.*

Pinus Cembra, L. Arolla Pine (Fig. 59). May reach 60—70 feet or more; the crown may be conic and pointed but usually soon becomes irregularly spreading or rounded off,



Fig. 60. *Pinus Strobus*, L. 1, open ripe cone; 2, cone-scale viewed from below; 3, cone-scale viewed from above; 4, winged seed seen from above; 5, seed forcibly deprived of its wing and seen from below; 6, shoot with growing spring-shoots and two cones of the preceding year. (All reduced, after von Tubeuf.)

and often bushy. Bark greyish-brown, fissured and scaly. Branches whorled.

‡‡ *Cones long, cylindroid, and pendulous, 150—200 mm long. Needles slender and more or less drooping, bluish or greyish 100—200 mm. long.*

Pinus Strobus, L. Weymouth Pine (Fig. 60). A North American Pine with a tall, straight, terete stem bearing whorls of radiating slender branches, beautifully graduated in a tapering conical or conic-pointed head, though the lower branches may die and remain long on the trunk, as in the Spruce. Bark slate-coloured, remaining smooth for a long time, but fissured and rough on old stems. Leaves 10—12 cm. long, slender, in more or less drooping tufts of 5, and bluish-green. Cones long, pendulous and rather Spruce-like, owing to the thin scales.

Pinus monticola, Don, from North America, and *P. excelsa*, Wall, the Himalayan Pine are similar, but have longer needles and cones and are less often seen in the tall conical shape in this country.

It should be noted that the tapering conical-cylindroid form is common and characteristic in young Pines and Firs, but these usually lose this shape long before they are 50 feet high (see p. 67).

⊙⊙ *Branches of the pseudo-whorls sweeping forwards, but bearing spray with the leaves isolated—not in tufts of 2—5.*

▱ *Spray horizontally extended, branching right and left, and fan-like, with its linear leaves also displayed right and left in a comb-like pattern. Cones erect, scales falling from the axis.*

Abies pectinata, DC. Silver Fir (Figs. 15, 61). Tall tree 100—180 feet high; the terete stem clothed with regular pseudo-whorls of branches bearing opposite branchlets of

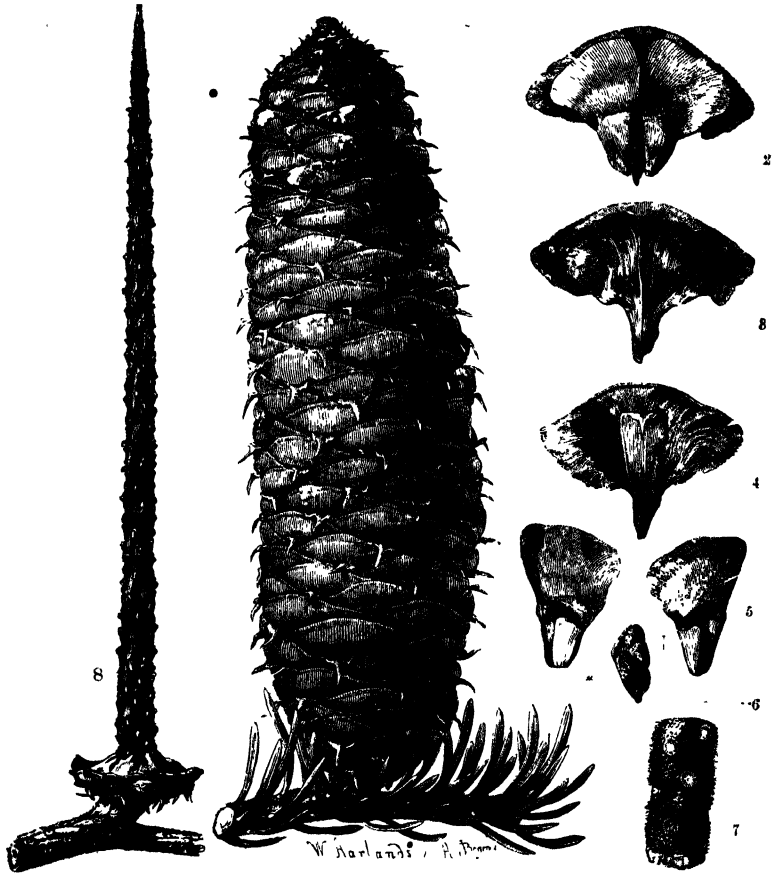


Fig. 61. *Abies pectinata*, Silver Fir. 1, ripe cone; 2, placental scale and seeds from within; 3, the same with seeds fallen; 4, scale from without, showing the smaller carpellary scale; 5, seeds with wing, the † points to the inturned part holding the seed; 6, seed with wing removed, the * points to a resin gland; 7, piece of shoot with leaf-scars; 8, axis of ripe cone from which the seeds and scales have fallen (Wi).

twigs expanded in the horizontal plane, the latter bearing crowded linear leaves arranged in a pectinate[1], apparently distichous, manner; leaves silvery below. Cones blunt with numerous thin closely imbricated scales. Crown pyramidal-pointed, twigs opposite (see also p. 156).

Many other species of *Abies* are met with in culture. Most of them have silvery or bluish-glaucous foliage, and all are distinguished from the Spruces (*Picea*) by the erect cones.

▱▱ *Spray of the lower branches more or less pendent right and left of the sweeping branches of the pseudo-whorls. Cones pendent and falling as a whole.*

§ *Leaves resembling those of* Abies *but not so decidedly combed right and left; branches not so decidedly in pseudo-whorls; cones with prominently exserted three-pointed bracts protruding from between the scales.*

Pseudotsuga Douglasii, Carr. Douglas Fir (Fig. 62). Tall North American Fir attaining 150—200 feet on the Pacific coast, with red-brown scaly fissured bark, and slender sweeping branches with upturned tips, bearing crowded spray with linear leaves all round, and often curved forwards. Remarkably feathery habit.

§§ *Leaves acicular-quadrangular; cones sub-cylindric with no projecting barren scales.*

Picea excelsa, L. Spruce (Fig. 62). General habit, narrow elongated, pyramidal-pointed, resembling that of Silver Fir, and attaining 100—150 feet, but crown more

[1] [The term "pectinate" (also represented in the specific name of *Abies pectinata*) here does not refer to the shape of the leaves, but is descriptive of their arrangement in a double comb-like pseudo-distichous pattern.]

conical, leaves not linear-flat, less pectinate in arrangement, and the whole foliage more gloomy; the lateral



Fig. 62. Cones of *Pseudotsuga Douglasii* (on the left), and *Picea excelsa* (on the right) (V and Wi).

branches bearing more sweeping and pendent spray, often upturned at the tips and the cones pendulous.

Many other species of *Picea* are met with in cultivation.

In the Larch and Cedars, especially *Cedrus Deodara*, there is a tendency to whorled branches while the tree is young, but irregularity supervenes at an early age by the casting or arrest of some of the branches, and they are normally not in pronounced pseudo-whorls round the stem. The same is also true, to a less extent, in the Douglas Fir.

The Larches and Cedars are readily known from all other trees by their narrow leaves in knob-like tufts of 25—50 or even more, distributed along the twigs: those of the Cedars evergreen, those of the Larch deciduous.

It should be noted also that *Prunus Padus*, *P. Avium* and even the Ash (*Fraxinus*) display a tendency to have their branches in false whorls sometimes, but the phenomenon is not sufficiently pronounced for diagnostic purposes here.

†† Branches not in definite pseudo-whorls, but radiating irregularly round the stem.

[For (⊙⊙) see p. 155.]

⊙ *Conifers with narrow linear, acicular, or scale-like leaves.*

□ *Evergreen shoots and slender branches crowded with small, green, imbricated, scale-like leaves, which are opposite and decussate. Cones small and round or oblong.*

§ *Shoots flattened, cones long-ovoid, of few opposite scales.*

Thuja gigantea, Nutt. Arbor Vitæ (Fig. 63). A North American form attaining 150—200 feet, and even in England tall and tapering.

Several other species of *Thuja* are cultivated in gardens.

§§ *Shoots quadrangular; cones spheroidal with angular scales.*

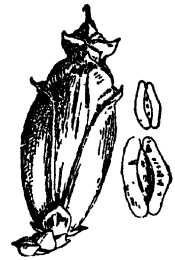


Fig. 63. *Thuja gigantea.* Ripe closed cone and winged seed (both magnified) and seed (natural size). (After von Tubeuf.)

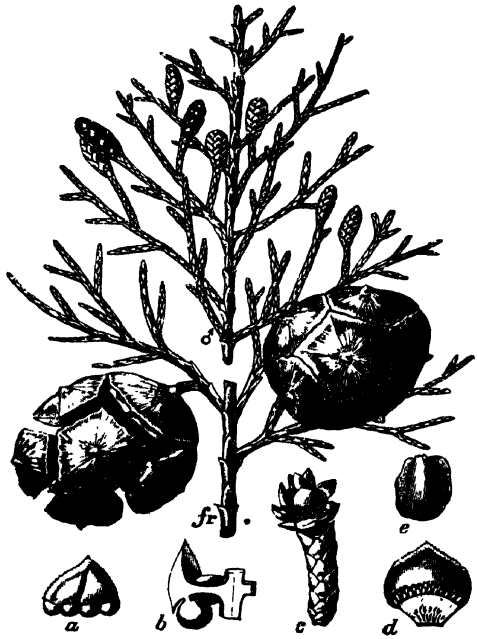


Fig. 64. *Cupressus sempervirens*, L., Roman Cypress. ♂ shoot with staminate flowers; *fr* shoot with ♀ cones; *a* stamen seen from behind; *b* the same in longitudinal section; *c* a ♀ flower; *d* one of its scales seen from within, showing the numerous erect ovules; *e* seed (E and P).

Cupressus sempervirens, L. Roman Cypress (Figs. 55, 64). A Mediterranean species attaining 100 feet or so. Oftener seen in the fastigiate variety (see p. 134).

Several other species of *Cupressus* are cultivated in gardens.

□□ *Leaves not scale-like nor imbricated.*

[For (§§) see p. 153.]

§ *Evergreens with narrow, linear, or acicular, dark glossy-green leaves.*

♯ *Leaves isolated and extended in flattened fan-like horizontal spray. Bark red-brown and scaly. Seed half immersed in crimson fleshy pulp ("Yew berry").*

Taxus baccata, L. Yew (Fig. 65). The Yew may attain a height of 30—50 or even more feet, but has then a very irregular lobed or bushy crown; some forms are more or less conical from a rounded base up to 8—10 feet high.

Foliage dark and dense, with the linear leaves arranged in a pectinate manner. Bark grey-reddish-brown, exfoliating in scales: trunk channelled. Seed single, slaty-brown or brown, exserted from a fleshy scarlet arillus.

Old Yews are widely spreading with more or less terraced foliage, and numerous other shapes are assumed by varietal and exposed forms of this slow-growing tree. Old stems are channelled and the much branched crown irregularly ovoid-conic to pyramidal, with exceedingly dense foliage.

♯♯ *Leaves stiff and acicular, in tufts of 50 or more scattered along the branches, which droop at the ends. Cones large.*

Cedrus Deodara. Deodar (Fig. 66). A Himalayan tree over 200 feet high, but lower in England. Crown conical [in ordinary specimens in British gardens]. The branches radiate but are not whorled, and rapidly ramify,

Fig. 65. *Taxus baccata*, Yew (Irv).

and produce dense fan-like spray drooping at the tips, as does the long leader, and so arranged as to give the



Fig. 66. *Cedrus Deodara*, the Himalayan Deodar (V).

impression of terraces or tiers of foliage (see p. 14). This terracing is even more marked in the stiffer spray of *Cedrus Libani* and *C. atlantica*. Bark dark grey, tinged with reddish-brown or purplish shades, and fissured and eventually scaly. Although the conical or pyramidal-pointed form is longest preserved in *C. Deodara*, it is, like *C. atlantica* from North Africa, merely a variety of *C. Libani*, the differences in their leaves, cones, &c. being insufficient to separate them; but in the last named the lower branches rapidly extend in succession, many are cast, and the rest form limbs which branch horizontally and display the spray in flat terraces as the crown rounds off (Fig. 6).

§§ *Deciduous tree, with reddish-grey scaly bark and very light open crown. Foliage of narrow acicular bright green leaves, in tufts of* 30—40 *as in* Cedrus, *but cast annually, leaving peculiar tubercle-like knobs on the slender branches; the latter few and more or less pendent, not displaying the spray in tiers. Cones small. Resinous tree.*

Larix europœa, L. Larch (Figs. 67, 68). Tree eventually up to 100 feet and more in height, pyramidal-pointed, but, long before attaining full height, losing the pyramidal form, owing to the lengthening of the upper shoots to equal the lower, and to rounding off at the apex.

The straight stem bears an open crown with sparse foliage, spreading or reflexed knotted branches, ending in up-turned shoots and bearing numerous slender pendent shoots. Foliage intensely green in early summer, then darker, in tufts of numerous leaves. Bark scaly and fissured, grey tinged with pink. Old cones small, brown and woody: young ones crimson. Male flowers yellow-green.



Fig. 67. *Larix europæa*, Larch (K).

The Cedars (*Cedrus*) are the only other trees with similar tufts of numerous leaves, but they are evergreen and the cones and habit differ completely.

*⊙⊙ *Evergreen, with leaves not acicular, but irregularly oval, spinose toothed, and highly polished. Not bearing cones. Flowers white. Berries red.*

Ilex Aquifolium, L. Holly. **Tree from 10—40** feet and often cylindroid-conic up to 20 feet. Bark greenish-grey, smooth for a long time, but eventually slightly fissured in fine streaks. The shoots remain green and glossy for years. Buds minute.

The only other common tree with leaves at all like the Holly is *Quercus Ilex*, but foliage of this is grey-green, its bark and crown very different, and its flowers and fruits (acorns) totally unlike those of the Holly.

The small bush *Berberis Aquifolium* also presents superficial resemblances only to a young Holly, the leaves being compound.

** Crown not tapering to a point, but more or less rounded off at the apex. Foliage more or less wanting below, exposing a clean stem. General shape cylindroid, long-ellipsoid, narrow-oblong, or broad-columnar.

† Main branches in more or less definite pseudo-whorls on the stem, which is terete and runs straight through the crown. Conifers with narrow acicular or linear leaves, evergreen. Trees up to 50—60 feet or so in height. [For (††) see p. 156.]

⊙ *Spray horizontal and fan-like, leaves isolated and pectinate in arrangement. Cones large and erect, the scales falling and leaving the axis exposed.*

Abies pectinata, DC. Silver Fir (Figs. 15, 61). See also p. 144. Old trees, when the leader has gone, round off at the top and become cylindroid-columnar (see pp. 65–7). This shape is in marked contrast to that of the more pointed Spruce.

⊙⊙ *Radiating branches sweep forward with upturned ends bearing needles in tufts of* 5. *Cones small and fall as a whole.*

Pinus Cembra, L. Arolla Pine (see also p. 143). Very apt to be irregularly bushy, cylindroid-columnar, when 30—40 feet high.

Some other Pines assume more or less this form of crown at mid-age.

†† Not evergreen. Crown more or less open and irregularly long-oblong or cylindroid, stem not straight and often more or less lost in crown. Branches not whorled. Leaves not narrow nor crowded nor tufted.

⊙ *Tree* 30—50 *feet or more in height, with very light and open foliage and branching, very slender pale and pendent twigs on which are scattered tufts of* 30—40 *leaves, or tubercle-like knobs.*

Larix europœa, L. Larch (Fig. 68, see also p. 153). In its older stages the Larch loses its leader, the upper branches grow to the length of the lower, and the crown becomes more or less oblong or cylindroid (see p. 153).

⊙⊙ *Twigs and branches not tuberculate, and leaves not acicular. Flowers not in cones.*

▱ *Foliage and bark very dark, almost black in mass. Leaves more or less obovate. Flowers in catkins; old, oblong, woody, black, cone-like, fruiting catkins often remain on through winter.*

[For (▱▱) see p. 160.]

Alnus glutinosa, L. Alder (Figs. 69, 70). The tree may reach 100—120 feet in height but is not often seen over



Fig. 68. *Larix europæa*, DC., Larch. 1, branch bearing a long shoot and several dwarf shoots, and (*a*) a proliferous cone; 2, shoot with male (♂) and female (♀) flowers; 3, male flower; 4 and 5, unopened, and 6, ruptured stamens; 7 and 8, scale of female flower seen from without and within; 9, ovuliferous scale; 10, cone; 11—14, seeds; 15, dwarf-shoot in section; 16, leaf and its section (Wi).



Fig. 69. *Alnus glutinosa*, Alder (Ro).

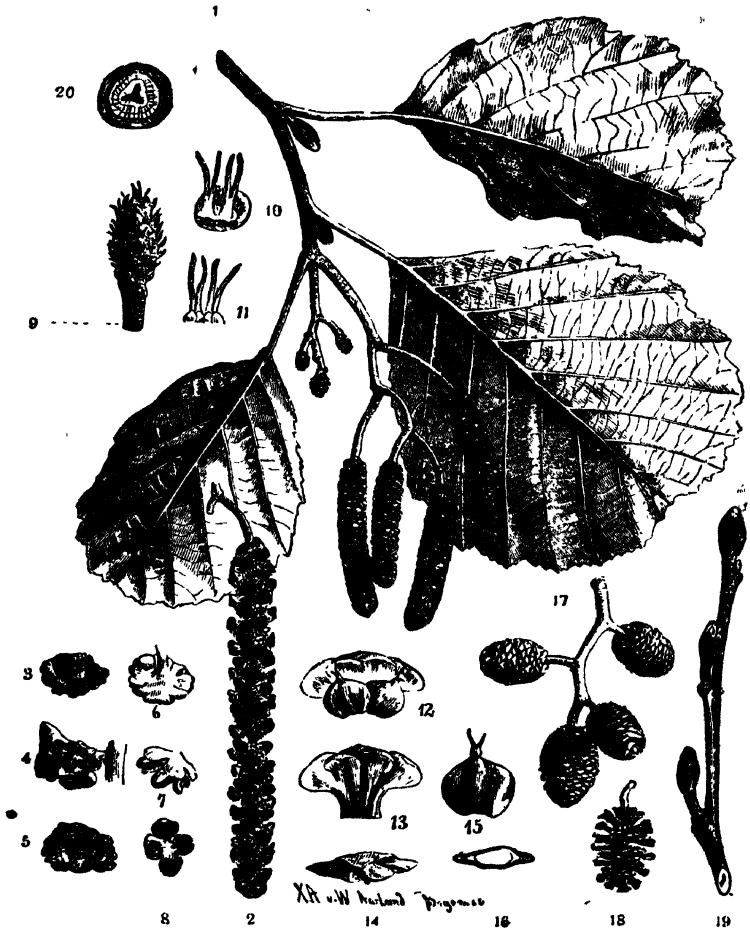


Fig. 70. *Alnus glutinosa*, Alder. 1, flowering shoot with young male and female catkins; 2, a male catkin; 3, one of the scales of the latter bearing three male flowers and their bracteoles, seen from outside; 4, the same in lateral view; 5, the same from inside; 6, the same from above; 7, a single male flower from outside, and 8, from inside; 9, a female

catkin; 10, one of its scales bearing two female flowers, seen separately in 11; 12—14, fruiting scales seen from above, from below and from the front; 15, 16, the fruit whole and in section; 17, ripe cone-like fruiting catkins; 18, one of the cone-like catkins after shedding its fruits; 19, a twig; 20, section of branch (Wi).

50 feet. Crown usually more or less oblong. Bark on old stem deeply fissured, with broad flat ridges cut into scales by cross fissures: remaining smooth and slate-coloured to deep olive-black for a long time on the branches. The curious oblong black cone-like empty infructescences, in branched groups of three or four, are unmistakable. Buds stalked and purplish.

▱▱ *Foliage not black in the mass, but bright or pale green; bark not black-olive. No woody cone-like catkins. Stem more or less branched and lost in the crown, and limbs ascending at acute angles.*

§ *Heavy, but bright green foliage. Spray distichous and much branched, the twigs curved and crossing in a light tracery. Crown irregularly elongated and diffuse. Bark deeply fissured, dark grey; stem very apt to throw out epicormic branches. Flowers purplish-brown in tufts, followed by flat oval winged samaras.*

Ulmus campestris, L. Common Elm (Figs. 71, 97). Crooked tall stem breaking above into a roughly cylindroid head with irregularly spreading, zig-zag branches, and trellis-like distichous spray; buds small. Foliage bright green, as are also the flat oval fruits derived from the very early dense tufts of purplish-brown flowers. Crown often conical with long bare stem, strong ascending limbs and close branches. (See also p. 202.)

§§ *Foliage light, and branching sparse, so that the crown is open. Bark not deeply fissured nor dark grey.*

Twigs thick and rigid, decussate ascending or upturned at the ends, smooth and grey-greenish; bark greyish fissured. Buds large and black. Leaves pinnate greyish-green, large. Flowers purple in tufts, followed by long oblong winged samaras.

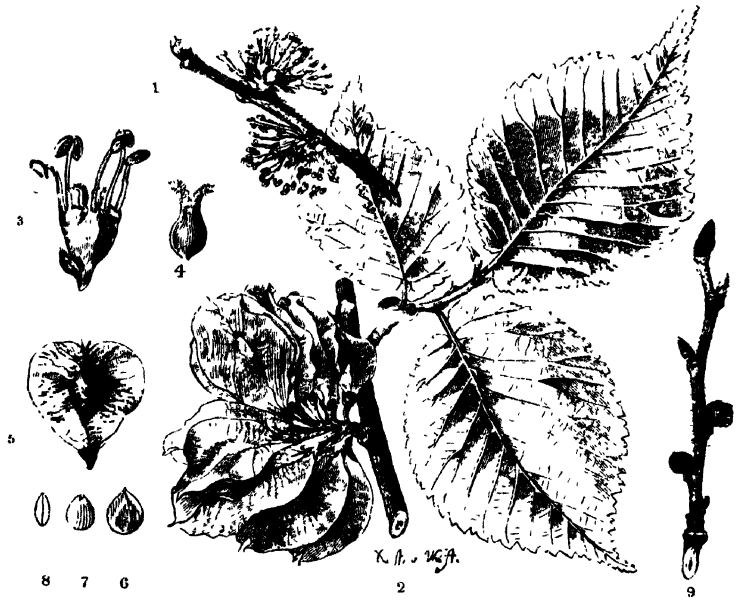


Fig. 71. *Ulmus campestris*, Elm. 1, flowering shoot; 2, twig of the preceding year, with tuft of fruits and a dwarf shoot bearing foliage; 3, a flower; 4, ovary; 5, fruit; 6—8, seeds; 9, buds (Wi).

Fraxinus excelsior, L. Ash. Reaching 80—100 feet. The regularity of the crown much affected by the bending over of the branches, which sometimes, on the other hand, tend to be sub-verticillate. (For more complete description see p. 189.)

‡‡ *Twigs very slender and long, more or less pendent, branching alternate. Periderm peeling in long white papery films round the stem and branches, which are often silvery white. Leaves loosely hung.*

Betula alba, L. Birch (Figs. 44, 72). The tree may reach 70—80 feet but is rarely seen over 50 feet. The irregular white-barked stem and graceful, more or less



Fig. 72. Birch (*Betula alba*): smooth bark (Irv).

drooping, and very open crown are characteristic. Old trees form a black and white very rugged fissured and stony hard bark at the base. Crown often ovoid-pointed. Suckers are developed.

(β) *Crown not more than twice as high as broad, or thereabouts, and usually on a definite length of bare stem. General form of crown more or less pyramidal, oblong or spheroidal*

* Crown pointed above, more or less spreading below. General shape pyramidal-pointed, base broadly rounded or somewhat narrow. [For (**) see p. 164.]

† Evergreens more or less densely clothed with foliage (see pp. 136—55).

The pointed pyramidal or conical form with tapering apex is the typical one for young Firs, Pines and other Conifers. Hence the student will often find species of *Abies*, *Picea*, *Pseudotsuga*, *Larix*, *Cedrus*, and *Pinus*, under 30 feet high, retaining this shape though they lose it later.

As they lose the lower branches and expose a greater length of bare stem, the characteristics of the bark begin to be visible, and a modification of the long cylindroid-conic form, clothed with foliage from base to apex, is obtained, viz. more or less definitely pyramidal crown on a shorter or longer stem. This may pass later into various other shapes (see pp. 67—9. Consult pp. 74—8). *Ilex Aquifolium*, with pyramidal crown, also comes here.

†† Deciduous trees especially in the sapling stage, more or less open in the crown, and lightly clothed with foliage in summer, best distinguished by buds and leaves (see pp. 79—90).

Under the head of pointed-pyramidal forms may be placed a number of saplings and young stages of trees,

which acquire very different shapes as the leader is lost and the crowns become rounded off at the top. Among these may be mentioned the Oaks, Plane, Elms, Lime, Alder, Birch, Hornbeam, Beech, Chestnut, Walnut, Willows and Poplars, all with their young branches arranged alternately and spirally round the main stem; further the Horse-chestnut, Maples, Ash, &c., all with the young branches and twigs opposite and decussate. None of them retain the tapering pyramidal form for long, but as the leader dies off, or slows down in its growth, the branches below rapidly assert themselves, and many of the twigs in the interior of the crown die off, producing the irregularity of form so well known in these round-headed—as opposed to pointed—trees.

It would occupy too much space to describe these transient forms of trees, from 10—20 feet or so in height, in further detail here. Those cases in which the pyramidal form is retained longer will be found below: the others must be sought for among the round-headed trees. When leaves and flowers are present the discrimination is easy; when absent the diagnosis may have to be sought for in the Section on Buds, &c. The Beech is apt to retain the pointed-ovoid or pyramidal form for some time.

** Crown rounded at the apex, broadest at the base or near the middle. General shapes oblong, ellipsoid, ovoid or obovoid, dome-shaped or more or less spheroidal.

[For (††) see p. 182.]

† Bark not rugged with conspicuous deep longitudinal fissures or rough ridges; smooth for a long time on the limbs, and often on the trunk.

[For (⊙⊙) see p. 170.]

⊙ *Bark, or superficial periderm, whitish-grey to slaty-grey, persistent and smooth, even on the trunk; limbs and principal branches*



Fig. 73. *Fagus sylvatica*, Beech (K).



Fig. 74. *Fagus sylvatica*, Beech. 1, shoot with a group of ♀ flowers above, and ♂ catkins below; 2, a male flower; 3, stamens, and trans-

verse section of anther; 4, two female flowers in their cupule; 5, ovary, advancing towards maturity; 6 and 7, the same in section; 8, fruits exposed by the splitting of the cupule into four valves; 9, the same before splitting; 10, seed in section; 11 and 12, buds (Wi).

coming off at acute angles. Spray distichous

▭ *Trunk cylindrical, not fluted nor buttressed; foliage smooth, shining and very dense; buds long fusiform, tawny-brown, very pointed, distichous, and many-scaled; ♂ flowers in tassel-like pendent tufts, fruits trigonal in prickly cupules.*

Fagus sylvatica, L. Beech (Figs. 47, 73, 74). Tree 100—120 feet, and often ovoid-pointed, passing to dome-shaped or broadly rounded pyramidal, owing to the extension and bending over of the lower branches. Spray distichous and upturned; with numerous ringed dwarf-shoots. Foliage passing through shades of olive to deep green, shining, more or less oval. The old woody prickly cupules, split into 4 valves, often remaining on through the winter. In young trees, and in clipped Beech hedges, the leaves, dead and brown, may also remain on through the winter. The stem is often traceable far up to the top of the crown, the limbs and branches coming off at acute angles. Twigs olive to slaty-grey, with numerous lenticels.

▭▭ *Trunk irregularly fluted or buttressed, branches at acute angles and almost erect (20—30° with vertical). Buds rather like those of Beech, but shorter and relatively fatter, more appressed, and with fewer scales. Foliage dull, Elm-like; flowers in loose catkins; fruits winged with large trifoliate bracts.*

Carpinus Betulus, L. Hornbeam (Figs. 75, 76). Rarely as tall as 60 feet, and with many resemblances to Beech, but usually with a bushy ovoid and sometimes more or

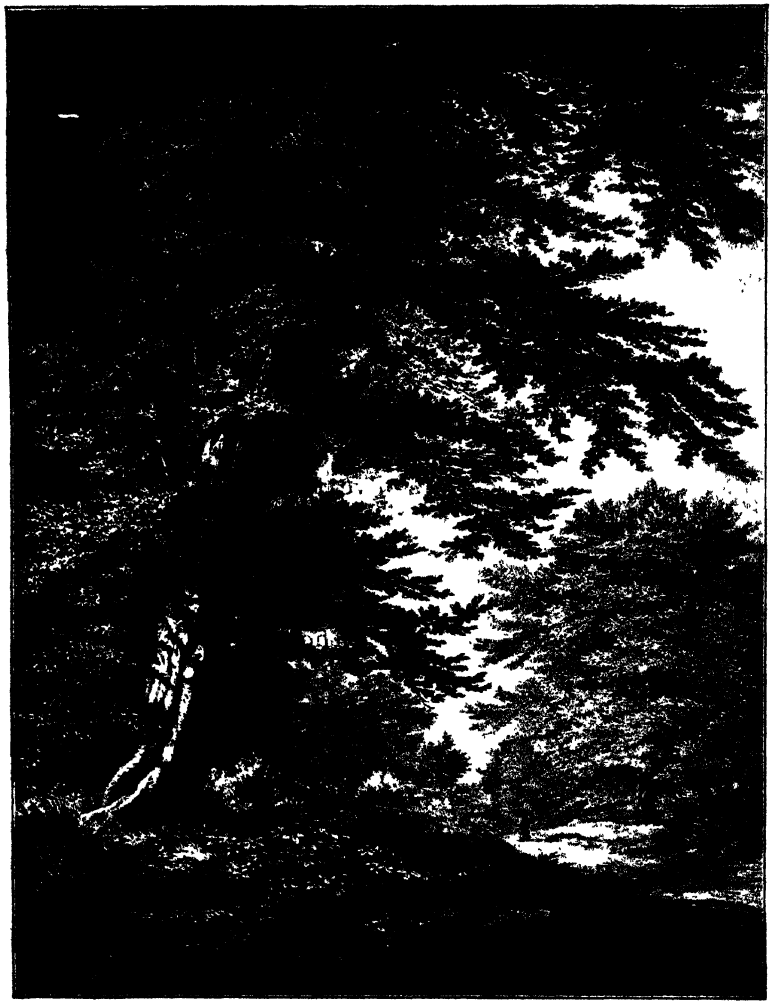


Fig. 75. *Carpinus Betulus*, Hornbeam (Ro).

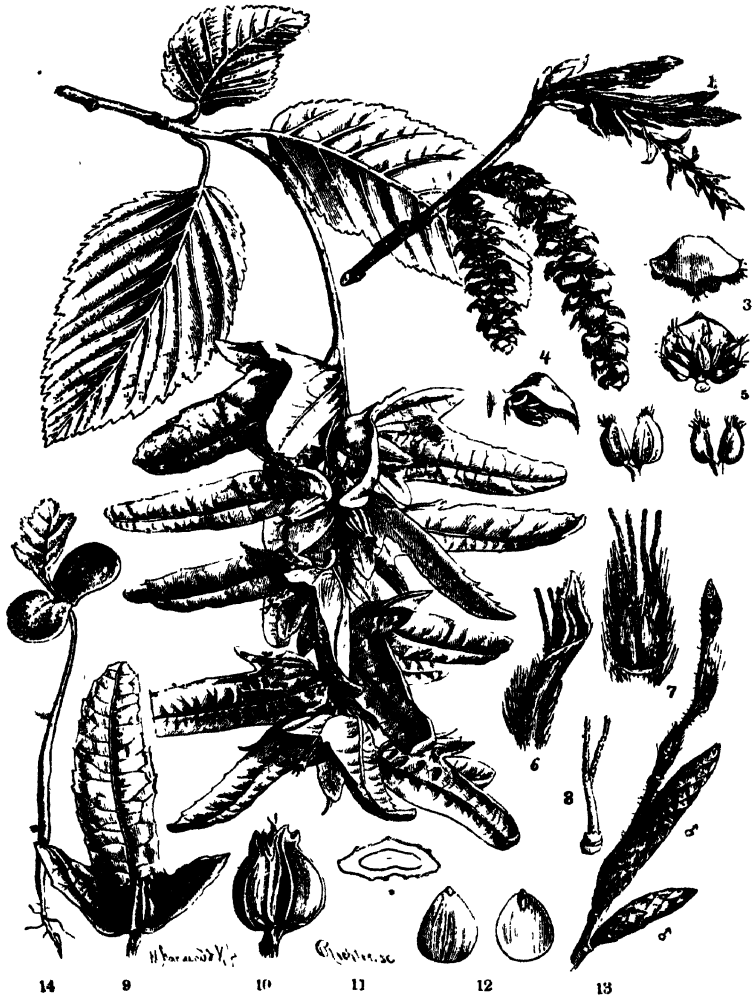


Fig. 76. *Carpinus Betulus*, Hornbeam. 1, flowering shoot with two male catkins below and a female catkin above; 2, a fruiting catkin; 3, scale of male catkin from in front; 4, the same from the side, and 5

from inside, showing the stamens, of which two are also seen separated and viewed from behind and from the front; 6 and 7, pair of female flowers enveloped in their bracts and bracteoles; 8, a separated female flower; 9, fruits and cupule; 10, fruits; 11, the fruit in section; 12, seeds; 13, buds; 14, seedling (Wi).

less pointed crown, through which the stem can be traced. The buds are shorter than those of Beech, more ovoid, and not so divaricate. Leaves very like those of Elm, but plaited. The fluted stem and serrate leaves, the buds, and the fruit at once distinguish it from the Beech; and the smooth, pale [or dark] grey bark, and bracteate fruits in catkins, from the Elms.

⊙⊙ *Bark, or periderm, not persistent on the trunk and limbs, but cast in strips or plate-like scales.*

[For (▱▱) see p. 175.]

▱ *Periderm peeling or flaking in thin papery strips round the limb or stem.*

§ *Periderm silvery-white and opaque, peeling in broad thin papery lamellæ marked with the transversely elongated brown lenticels. Branches slender and at acute angles, the twigs particularly thin and overhanging; with very light open foliage, and pendent catkins.*

Betula alba, L. Birch (Figs. 72,77, see also p. 162). Very old trees form a peculiarly rugged and hard knobbly bark at the foot of the trunk. The latter is tapering, sinuous, traceable more or less through the oblong or ovoid or rounded pyramidal crown, the branches obliquely ascending and very loose. The leaves are rather small, more or less rhomboid-ovate, and loosely hung. Flowers in pendent catkins.

There is no other common tree like it. The fine twigs reddish-brown, polished, with prominent verrucose lenticels; the opaque white periderm, interlaminated with brown cork, appears first on the branches.

§§ *Periderm reddish or coppery-brown, with a silvery glance on the very thin exfoliating laminæ, but not opaque white. Small trees; leaves not rhombod; twigs stiff and erect, or, at least, not very slender and pendent.*

‡ *Small catkin-bearing tree, usually converted into a shrub by the numerous shoots thrown up from roots and*

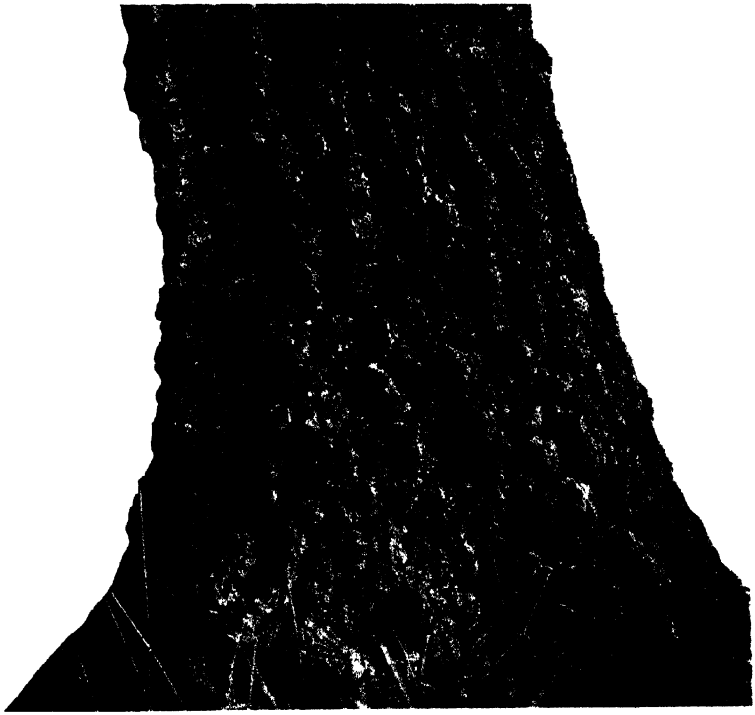


Fig. 77. Birch (*Betula alba*): rough bark and base of stem (Irv).

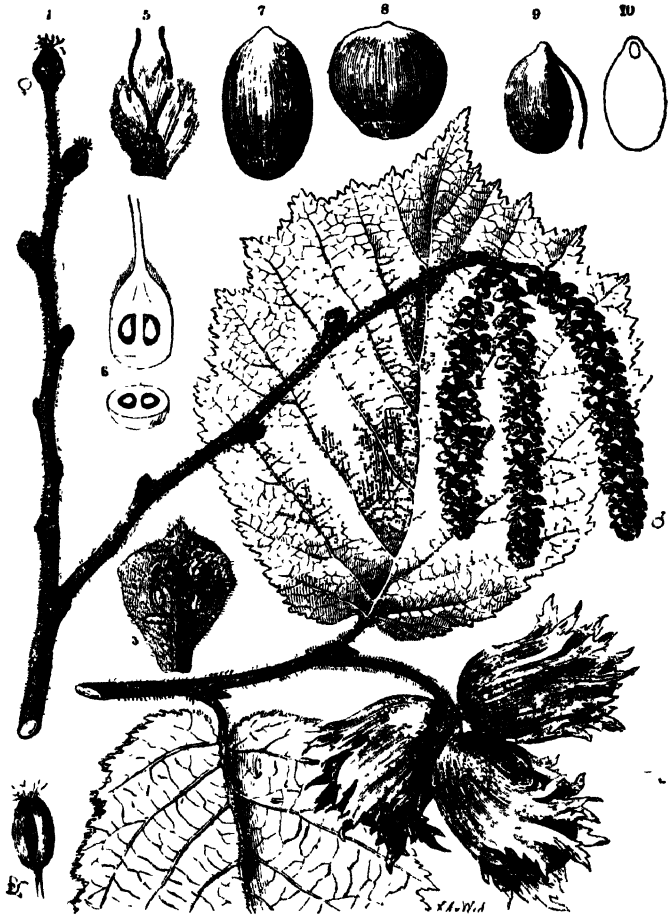


Fig. 78. *Corylus Avellana*, Hazel. 1, twig with ♂ and ♀ flowers; 2, leaf and nearly ripe fruits; 3, scale, bearing ♂ flower; 4, a stamen; 5, female flower invested by the young involucre; 6, sections through ovary; 7, 8, nuts; 9, 10, kernel (embryo) (Wi).

collar; leaves broad, more or less obovate, and distichous on the lateral shoots. Nuts in fringed foliaceous cupules.

Corylus Avellana, L. Hazel (Fig. 78). The shoots are greyish and glandular-hairy, the older twigs red-brown with exfoliating paper-like epidermis, and abundance of lenticels. This passes to a condition in which the periderm is peculiarly shining and coppery, and as if tightly stretched on the branch, very like the condition in certain Cherries.

The twigs are often very long and switch-like, especially in Coppice, and have the buds, leaf-scars and leaves distichous. The glandular-hairy shoots and the periderm at once distinguish it from the otherwise somewhat similar Elm.

‡‡ *More or less round-headed, small trees with the smooth stems traceable into the crown and numerous evident dwarf-shoots in groups. Leaves tufted, more or less oblong-lanceolate, never distichous. Flowers rosaceous, and fruits drupaceous.*

Prunus Cerasus, L. Cherry. Tree about 20—25 feet high, with the stem traceable in the crown. Branches spreading, and twigs often pendent: the elongated smaller branches emitted from the larger wide-angled ones are erect or overhanging, and have prominent dwarf-shoots in tufts. Often exuding gum.

Prunus Avium (which may be a large tree, Fig. 79) is with difficulty distinguishable, but usually has a pyramidal crown, more pendent and flaccid leaves and sweeter fruit, and the dwarf-shoots are grouped more along the long shoots instead of being aggregated at the ends. The

branches are few, divaricate-erect, and often sub-verticillate, often have a coppery lustre, and the long transverse lenticel-streaks are very prominent.

Prunus Amygdalus, L. The Almond, with rounded crown and spreading branches, may also be placed here.

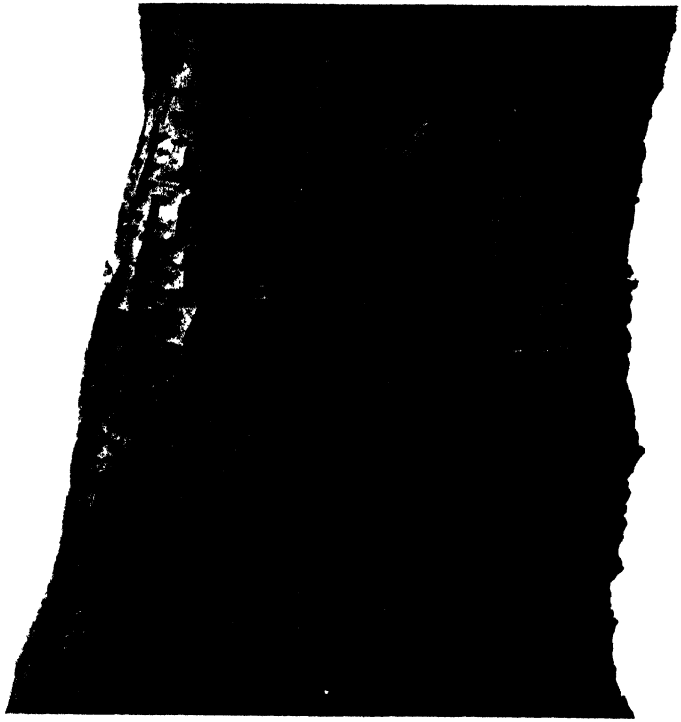


Fig. 79. *Prunus Avium*, Gean. Bark (Irv).

Prunus Padus, L. With rounded crown and few spreading branches, inclined to be sub-verticillate, also comes here; as well as *P. domestica*, L. and *P. insititia*

with rounded crowns of spreading sub-erect branches, and forming suckers, but they are often shrubby (see p. 233).

In addition to their lack of glandular hairs, and the spiral, instead of distichous, arrangement of the buds, leaf-scars, leaves, &c., the species of *Prunus* are distinct from *Corylus* in exuding gum from the cortex, and the young catkins are often observable on the latter in winter.

▱▱ *Bark not peeling in thin papyraceous films, but cast in more or less sharply circumscribed, rounded or angular, patches or scales.*

§ *Bark olive-grey, nearly smooth, but annually casting even in early youth thin irregularly rounded plates, which leave exposed patches of paler grey, olive or yellowish hues. Limbs and main branches off at wide angles, tortuous and rather oak-like; spray irregular and crown dome-shaped or round spreading. Foliage thick and leaves large. Flowers and fruits in globoid button-like heads on pendent stalks.*

Platanus orientalis, L [and *P. acerifolia*]. Plane (Fig. 80). Spreading tree 60—80 feet in height, the stem traceable far into the loose crown, whose tortuous branches come off at wide angles. The peculiar bark and button-like fruits are unmistakable.

Platanus occidentalis, the Button wood of North America [which is very rare in this country], has the palmatifid leaves less deeply cut and retains its tomentum longer. The buds are covered up by the bases of the petioles, and the stipules are peculiar, being collar-like. Huge spreading tortuous limbs and cover thick as that of a Beech.

§§ *Bark not olive-grey nor exfoliating large thin plates leaving parti-coloured patches; but casting slowly smaller or larger scales of various kinds, when old.*



Fig. 80. Plane: scaly bark (Irv).

‡ *Evergreen tree, often shrubby in habit, with dark green linear leaves, and casting reddish rough scaly plates from the old trunks.*

Taxus baccata, L. Yew (Fig. 65). Better recognised by its other characters (see p. 150).

Quercus Ilex may also be mentioned here, as its scales are sometimes pronounced, though preceded by fissures (see p. 194).

‡‡ *Deciduous trees, not casting red scales; leaves broad. Large trees with more or less pyramidal-domed, spreading heads, decussate spray and leaves, and large terminal buds.*

÷ *Limbs and larger branches sweeping downwards and forwards, spray upturned and bearing very large viscid red-brown buds, or, opposite large digitate leaves. Bark deep slaty-brown cast in irregular angular rough scales. Flowers on large erect pyramidal inflorescences; fruits spinescent, shedding big round red-brown seeds.*

Æsculus Hippocastanum, Horse-chestnut (Figs. 81, 83). The foliage is beautifully displayed and more or less terraced, bright green. Flowers large and irregular, white touched with red and yellow. The huge globoid seeds of the Horse-chestnut must not be confounded with the similarly coloured fruits of the true Chestnut. Crown ovoid-pyramidal in young trees, and twigs stiff.

No other tree, except certain other species of the same genus and of the allied *Pavia*, present the peculiar large, ovoid, upturned and viscid buds of *Æsculus*. The forward sweep of branches and upturning of the tips is met with in the Pines, Beech and Ash, but is hardly characteristic of any other large tree.

÷ ÷ *Limbs and large branches extended, but not upturned; bark rough and small-scaled, grey; buds smaller, not viscid or red-brown, but olive-*

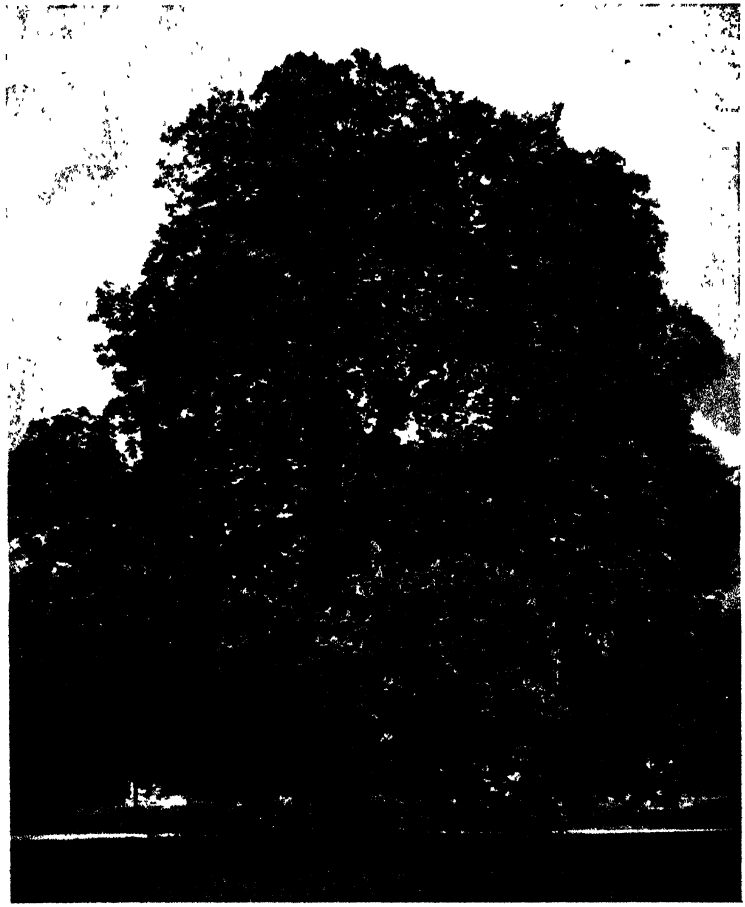


Fig. 81. *Æsculus Hippocastanum*, Horse-chestnut (Irv).

green. Leaves simple large palm-ilobed. Flowers greenish in pendent racemes. Fruit a winged double samara.



Fig. 82. *Acer Pseudo-Platanus*, Sycamore (Irv).

Acer Pseudo-Platanus, L. Sycamore (Figs. 82, 84, 110). The absence of milky latex, the pendent racemes, the scaly, not fissured, bark, and the buds distinguish it from other Maples. Crown ovoid-conic to broadly pyramidal-domed,

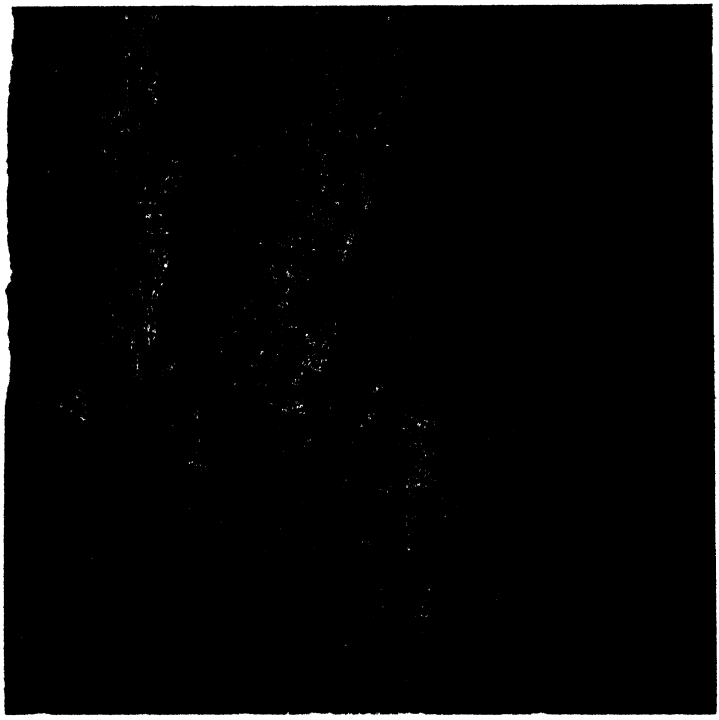


Fig. 83. *Æsculus Hippocastanum*, Horse-chestnut. Bark (Irv).

somewhat like that of Beech, but easily distinguished by opposite twigs, &c.

Some care will have to be exercised in comparing this group of truly scaly-barked trees, with those in which

the bark is primarily fissured by longitudinal clefts, but the ridges between are further cut transversely by cross-cracks, which break the ridges up into more or less angular scales. This occurs especially in species of *Pyrus*, and to

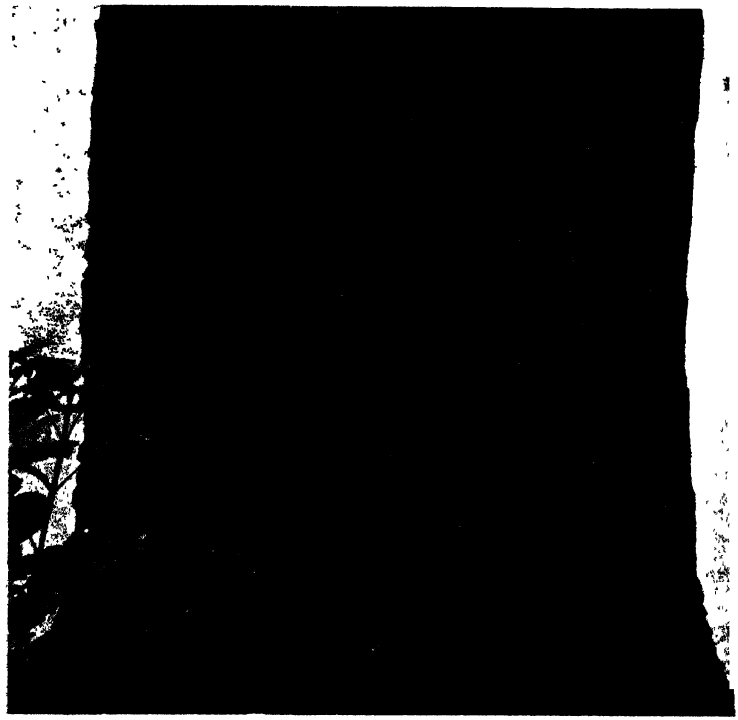


Fig. 84. *Acer Pseudo-Platanus*, Sycamore. Bark (Irv).

such an extent in *Pyrus Malus* and *Cratægus* that it would be almost as convenient to place them here as in the other group. The phenomenon is also more or less characteristic of *Pyrus communis*, *P. Sorbus*, *P. torminalis*

and others. It is also characteristic of *Quercus Ilex*, of *Alnus*, and, to a certain extent, of some Elms (e.g. the var. *Ulmus effusa*) and of *Populus alba* and *P. tremula*, as well as of *Morus* (see below, p. 187).

Truly scaly bark also occurs in some Conifers, e.g. *Pinus sylvestris*, *Taxus*, &c., but these have been already dealt with by characters of the persistent foliage, &c.

†† Bark of stem sooner or later with evident longitudinal fissures.

(N.B. This is also true of *Salix babylonica*, *Populus nigra* var. *pyramidalis*, *Pinus sylvestris* and other Pines, *Alnus glutinosa*, *Ulmus campestris*, *Fraxinus excelsior*, already dealt with on account of other prominent characters.

The following trees do not show the fissures until the tree is rather large, and 20—30 feet or so in height: *Æsculus*, *Tilia*, *Fraxinus*, *Juglans*, and *Populus alba*. Several smaller trees remain for many years devoid of definite fissures, e.g. *Cytisus Laburnum*, species of *Prunus*, *Pyrus*, &c., and there is danger of mistaking such for smooth-barked trees.)

[For(⊙⊙) see p. 205.]

⊙ *Crown taller than broad, slightly elongated —i.e. ovoid or obovoid, oblong, rounded-pyramidal, dome-shaped or more or less spheroidal.*

[For (▱▱) see p. 193.]

▱ *Predominant colouring of branches and stems pale: greenish-white, grey or buff tints.*

(Pale grey to buff tints are less common than the darker hues in trees, especially apart from the foliage. Greyish foliage and young growths are characteristic of some Willows, White Poplar, Aspen, Ash, *Pyrus Aria*, *Quercus Ilex*, and a few others, but the trees of the present section have pale-tinted branches in winter,

though their foliage in summer may be bright or even dark green.)

§ *Small loose crowned trees, not more than about 20—25 feet high, and may be little more than shrubs.* [For (§§) see p. 187.]

‡ *Twigs stout, long, erect, and not pendent nor plumose: internodes long and leaves large, pinnate and opposite; bark corky, pale tawny, deeply furrowed. Flowers white in dense corymbs: fruits black berries.*

Sambucus nigra, L. Elder (Fig. 85). Bark reminding one to some extent of *Acer campestre*, but much coarser. The long internodes and switch-like suckers and twigs, with opposite fringed buds, and the large pinnate leaves, more or less umbellate cymes, dark berries, &c. are very characteristic. So, also, is the bushy habit, with a tendency to fling over the branches in curves, giving off erect switch-like branches which, like the suckers, have a large pith. Suckers straight and erect.

‡‡ *Twigs not stout and leaves not pinnate; fissures of bark very shallow; flowers not white and fruit not fleshy.*

÷ *Crown rather rounded, the stem soon lost in branches at acute angles. Branches few, stiff, green and smooth for a long time, and then with a but slightly fissured olive-grey bark. Leaves ternate silky-whitish. Flowers yellow, papilionaceous, in pendent racemes. Fruit a legume.*

Cytisus Laburnum, L. Laburnum In flower the Laburnum is unmistakable, its pendent racemes of yellow papilionaceous flowers, followed by dull pendent

pods, and its silky and almost silvery-grey-green shoots and foliage of ternate leaves being almost unique. The dwarf-shoots are very short and knot-like, but the twigs may be long and whippy, with evident lenticels, olive-grey,



Fig. 85. *Sambucus nigra*, Elder. Base of trunk showing rough bark and erect switch-like shoots (Irv).

passing to dark grey. The buds are surrounded by persistent leaf-bases bearing stipules, and so appear fringed.

÷ ÷ *Prevailing hue of branches and stem pale tawny or reddish-grey;*

bark corky, often in high thin ridges on the branches, but shallow fissured on stem. Leaves green, palmately lobed. Flowers yellowish-green in erect corymbs; fruit two-winged.



Fig. 86. *Acer campestre*, Maple. Bark (Irv).

Acer campestre, L. Maple (Figs. 86, 87). Crown ovoid-conic to broadly pyramidal, and may be very densely branched. The small hairy buds, paler reddish-tawny bark, and the tendency, often very pronounced, to form prominent corky ridges, sometimes like wings, on even

young branches, distinguish *A. campestre* at once from *A. platanoides*, which is also a far larger tree with darker deepish grey bark. *A. Pseudo-Platanus* has scaly bark.

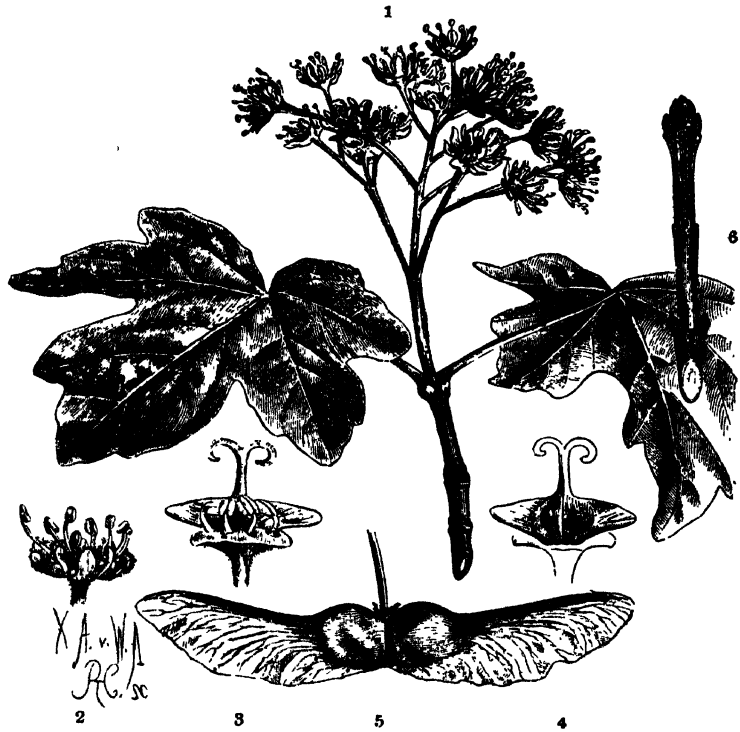


Fig. 87. *Acer campestre*, Maple. 1, flowering shoot; 2, male flower; 3, ovary and stamens on the glandular disc; 4, ovary; 5, fruit; 6, buds (Wi).

The best distinction between the three species, however, resides in the fruits, which are winged double achenes. The [pale] tawny deeply fissured corky bark of *Sambucus*

cannot lead to mistakes if the leaves and buds are compared.

§§ *Tall trees, over 40—50 feet in height*

Bark grey-whitish or greyish-green, tending to scale. Buds with several scales. Crown rounded, the stem traceable through it; branches off at acute angles, but some bend over; twigs thin and rather whippy. Foliage broad white below. Flowers in catkins; fruit capsular; seeds minute comose.

[For (‡‡) see p. 188.]

Populus alba, L. Abele (Fig. 88). Round-headed tree, 60—90 feet high, with the pale grey limbs and trunk which remain smooth for a long time, and then acquire fissures and broad ridges tending to break up into scales on old boles. The crown is ovoid-conic to rounded, providing medium curve as the branching is rather loose. Foliage of broad leaves, very white-cottony beneath, as is especially evident when they are upturned by wind. Twigs long and slender, grey-white and cottony.

Populus tremula, L. Aspen. This tree can only be distinguished from *P. alba* and the variety *P. cinerea* by details of the leaves and flowers (see Vols. II.—IV.), but it is usually a smaller tree with yellower and smooth, not cottony, twigs, and somewhat larger buds; and the leaves are more rounded and on longer petioles to which the trembling is due. Both species have a great tendency to throw up suckers. Crown broadly rounded, loose.

There are but few trees with the leaves white beneath (see *Pyrus Malus*, *P. Aria* and *P. torminalis*, pp. 197—9).

The two Willows, *Salix alba* and *S. fragilis*, the former of which has silky white leaves and shoots, and both of which may be greyish, are at once distinguished

by the narrower, lanceolate leaves and erect catkins, and in winter by the deeper olive branches, buds with one scale only, and fissured bark.

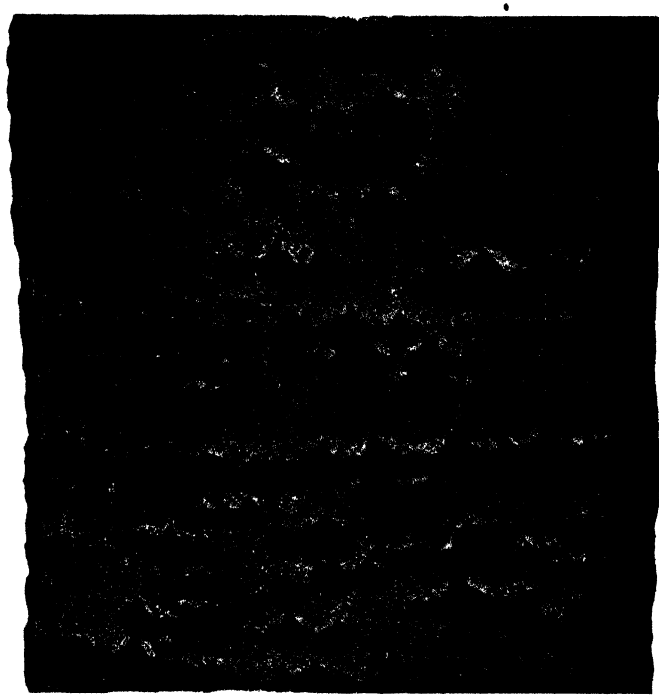


Fig. 88. *Populus alba*, Abele. Bark (Irv).

‡‡ *Bark not scaling, fissured. Crown elongated, rounded, pyramidal to ovoid, or sub-spheroidal. Twigs thick; leaves pinnate and not white tomentose beneath. Seeds not comose.*

÷ *Tree with a loose crown and radiating stout and few branches and twigs, the latter opposite and*

bearing pinnate leaves, black opposite buds, tufts of purple flowers, or pendent winged "keys."

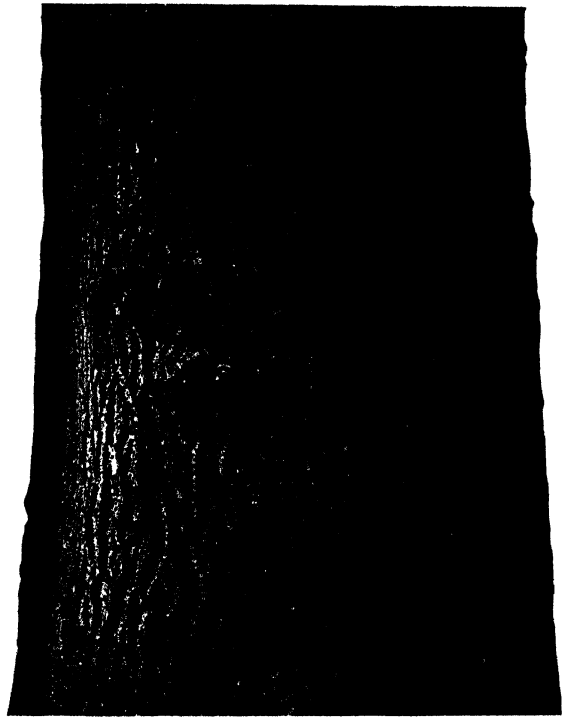


Fig. 89. *Fraxinus excelsior*, Ash. Bark (Irv).

Fraxinus excelsior, L. Ash (Figs. 89—91, see also p. 161). Large tree up to 80—100 feet in height, with an oval-pyramidal crown formed of few spreading, erect and stiff branches, more or less pendent thick twigs. Bark on old stems rather like Oak, but with more numerous and finer fissures; but the branches remain



Fig. 90. *Fraxinus excelsior*, Ash. 1, flowering dwarf shoots with hermaphrodite flowers; 2, female inflorescence; 3, 4 and 5, hermaphrodite flowers; 6, male flower; 7, ovary; 8 and 9, ovary in vertical and transverse section; 10, winter twig with fruits; 11, seed in section; 12, seed torn open; 13, seedling (Wi).

smooth and greenish-grey for a long time. Tree loosely branched and often showing a tendency to false whorls. Spray stiff and decussate, the twigs very stout and few, with black buds and pinnate greyish-green leaves. Flowers deep purple, in dense clusters, followed by long pendent winged achenes ("keys") or by barren stalks remaining late into the autumn. The opposite leaves, buds, and branches at once distinguish this tree from the Walnut; as also the inflorescences, flowers and fruit: ♂, ♀ and ☿ trees occur. Even in old trees the trunk can usually be traced through, and the tree tends to form suckers.

÷ ÷ *Trunk soon breaking into the limbs and not traceable through the crown: lower limbs coming off at wide angles. Large tree with thick alternate twigs, and main branches tortuous like those of the Oak. General colour of the bark pale, tawny-grey with yellowish shallow fissures on the trunk and limbs, reminding one of the Ash, but the buds not black and the spray alternate.*

Juglans regia, L. Walnut (Fig. 92). The Walnut has an ashen-grey periderm which may remain smooth and pale until the tree reaches 50—60 feet in height; and its richly branched and deeply foliaged crown has a large spread. On the other hand, old trees occasionally have a deeply fissured and darker greyish bark on the trunk.

The most certain test, in the absence of flowers and fruit, is the chambered pith, a peculiarity shared by no other common tree, and only met with in a few other species of *Juglans* and *Pterocarya*, and a few out-of-the-way forms.

The stem is usually bare and short and breaks into the limbs which run high and form few, thick and torulose branches. The cover is dense, and the tree aromatic.

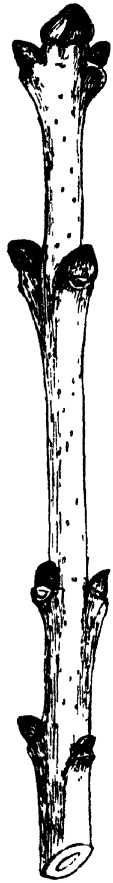


Fig. 91. *Fraxinus excelsior*, Ash. Twig (D).

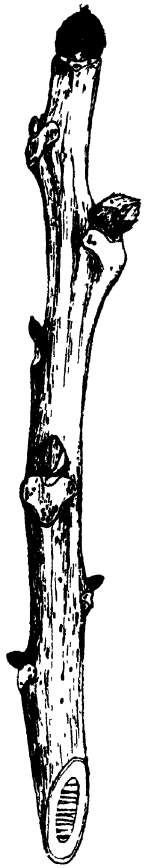


Fig. 92. *Juglans regia*, Walnut. Twig (D).

▱▱ *Predominant colouring of branches and stem dark: slate coloured, dark grey, olive, purple shades, brown or nearly black.*

§ *Small trees not over* 20—30 *feet high.* [For (88) see p. 201.]

‡ *Evergreen, with more or less spinescent grey-green foliage, and smooth slate coloured branches. Bark on old stems fissured and scaly, hard, slaty-black.*



Fig. 93. *Quercus Suber*, Cork Oak. Bark (Irv).

Quercus Ilex, L. Holme Oak. About 30—40 feet in height, with a somewhat narrow rounded-ovoid crown, dense grey-green foliage, and a slate-coloured finely fissured bark cut into small quadrangular scales; but often shrubby. Shoots greyish tomentose, passing to ash-grey smooth branches. Leaves spinose-toothed or entire.

Quercus Suber, L. Cork Oak (Fig. 93). Evergreen tree 30—40 feet or more, with irregular rounded crown, somewhat resembling *Quercus Ilex*, but with a deeply fissured very thick corky bark.

‡‡ *Deciduous trees.*

[For (8 8) see p. 197.]

8 *General hue of branches and stem grey, slate colour, or olive, and not red-brown. Bark fissured but not prominently scaly on the ridges.*

[For (Δ Δ) see p. 196.]

Δ *General hue of branches and twigs olive; young shoots grey hoary. Leaves lanceolate. Flowers in erect catkins; fruits capsular and seeds small comose. Buds with one scale only. Often as pollards.*

♂ *Leaves silky pubescent, white beneath [except when old]. Twigs not fragile at the articulations.*

Salix alba, L. White Willow (Fig. 94). Tree 60 feet or so in height, but rarely seen over 30—40 feet, and often pollarded. Crown elongated, rounded-ovoid, with numerous branches and long twigs, which are olive and polished; shoots silky pubescent, as are the leaves, giving the foliage a peculiar silvery-grey appearance. Bark deeply and coarsely fissured.

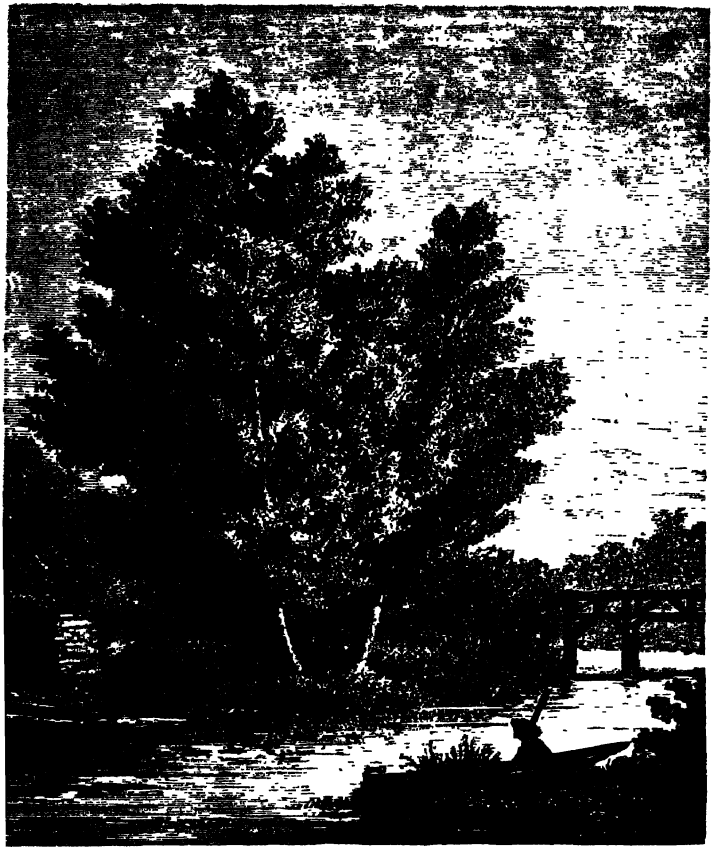


Fig. 94. *Salix alba*, White Willow (F).

∂∂ Leaves not silky pubescent nor white. Twigs fragile at the articulations.

Salix fragilis, L. Crack Willow. Very like *S. alba* in size and habit, but more cross-branched, and the shoots and leaves not silky. Its name is due to the marked fragility of the twigs, which dislocate at the insertions very easily, a peculiarity not shown by *S. alba*.

ΔΔ General hue of stem and branches dull slate colour or deep grey. Ridges of the fissured bark not prominently scaly. Leaves not lanceolate; flowers rosaceous, in corymbose inflorescences. Fruits fleshy.

Z Buds rather large, violet-black with grey pubescence; twigs slate coloured. Leaves compound, pinnate. Fruit scarlet in clusters.

Pyrus Aucuparia, Gaert. Rowan. The stem is traceable through the elongated crown. Branches with smooth grey periderm, twigs slightly pubescent. The twigs have a faint unpleasant odour when crushed. The tree shows a great tendency to form suckers below. Flowers and fruit in corymbose cymes. Autumnal leaves yellowish-brown.

The very similar *P. Sorbus*, occasionally seen, has similarly brown twigs, and also pinnate leaves, but the bark is browner and more scaly and the buds green, while the fruit is more pear-shaped and olive-brown. The crown is pyramidal.

ZZ Buds not black nor grey-black, but green or olive;

leaves not compound pinnate, but broadly ovate and lobed, white tomentose below; buds bordered brown and large, especially the end one. Fruits small, fleshy and red, spotted.

Pyrus Aria, L. White Beam. The general colour of the branches is slate-grey with large and prominent lenticels, even on the older ones. The fissuring of the bark is very shallow, and the twigs tend to be upturned at the ends. Crown often ovoid, the branches straight and robust; the tree produces suckers.

Pyrus torminalis is somewhat similar, but the leaves are more lobed and not so white, the twigs slightly angular (see *Populus alba*, p. 187). The tree produces suckers.

8 8 *General hue of branches and stem reddish to purplish-brown, or pure brown.*

△ *Shoots remarkably slender, more or less pendent, and densely crowded with imbricated small grey-green scale-like leaves, giving the tree a peculiarly feathery appearance. Branches purple-brown or reddish. Flowers small, pink, in dense spikes: fruits capsular, seeds comose.*

Tamarix gallica, L. Tamarisk. May reach 20—30 feet as a bushy tree, or may be a mere bush 6—10 feet high. Often near the sea. Twigs smooth and finely striate; branches slender, reddish, and often long and withe-like or curved, dark grey-brown, olive, and purple-

brown shades prevailing as they age. Bark deeply fissured on old stems, and may incline to tawny or brown. Branches long, smooth, with lenticels showing as transverse lines.

The only other trees with similarly scaly foliage are the Cypresses and Thujas, which have dark, not sea-green or glaucous, foliage, and are evergreen Conifers.

The capsules and comose seeds remind one of Willows, as also does the habit to some extent, but the leaves and flowers are quite different, as are all the details of buds, scars, spray, &c.

ΔΔ *Shoots, &c. not remarkably slender, nor with scaly leaves, nor plumose. Flowers not in dense spikes, seeds not comose. Bark fissured with tendency to scale on the ridges. Buds small. Flowers rosaceous, corymbose. Fruits fleshy.*

♂ *Crown elongated, oblong or ovoid, the stem traceable to the top. Ridges between fissures, which are rather deep, much cut into more or less rectangular scales; leaves glabrous, more or less ovate, and not lobed; flowers white; fruit* [*often*] *pyriform.*

Pyrus communis, L. Pear (Fig. 95). The short branches are numerous and tend to harden at the points to thorns; the elongated fruit narrows at the base into the stalk. Crown long erect pyramidal. Suckers common. Branches ascending. Shoots glabrous, more or less angular, olive to yellowish-brown.

dd *Crown sub-spheroidal, the stem soon lost in the branches which come off and ramify at all angles. The fissuring of the bark very irregular, and cross-cracks cut up the ridges into shallow scales.*

z *Not obviously spiny; leaves ovate and more or less grey tomentose beneath, as are the shoots. Fruit spheroidal, depressed at the stalk-end.*

Pyrus Malus, L. Apple (Fig. 96). Often shrubby and occasionally some of the dwarf-shoots (spurs) end in thorny points. The scaling is so pronounced sometimes that we might include this species under scale-barked trees; scales thin, very irregular and rough, grey-brown. Tree usually about 10 feet in height but may reach 30. Flowers pink and white. The crown is often rather rounded-depressed, broader than high.

zz *Thorny and densely branched; leaves lobed, not tomentose. Fruit red and soft "Haws."*

Cratægus Oxyacantha, L. Hawthorn. The Hawthorn, as a tree, has a rounded head and is usually about 10—20 feet in height, but may be 30; but it is often shrubby. The branches are polished and vary much in colour; grey-brown, purple-brown and orange or olive shades are common. The thorns are typically numerous and hard and sharp, but may be rare.

Among other trees with dark fissured bark, an oval or round-headed form, and a height of less than 30 feet are: the Mulberry (*Morus*), with broad heart-shaped or lobed

leaves, a milky juice, and a grey-brown, coarsely fissured bark, tending to scale on the ridges. *Ailanthus glandulosa*, best recognised by its great tendency to fork dichotomously, though the twigs are alternate, by the sharply marked

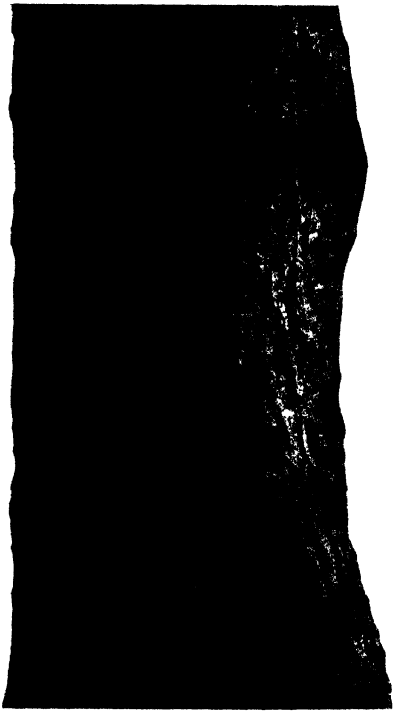


Fig. 95. *Pyrus communis*, Pear. Bark (Irv).

pale fissures in a deep brown bark, and by the long feathery pinnate leaves. In addition there are the Lime (see p. 204), and young Elms (p. 202), Oaks (pp. 206—9), Chestnuts (p. 210), Maples (pp. 185, 186, 216—9), Willows

(pp. 194—6), Poplars (pp. 213, 214), Alders (pp. 156, 202), and Horse-chestnuts (p. 177). These young or sapling stages of what normally become taller or large spreading trees may be looked for in the succeeding sections, or have been partly dealt with above.



Fig. 96. *Pyrus Malus*, Apple. Bark (Irv).

§ *Tall trees over* 50 *feet in height.*

‡ *Very dark tree with sombre foliage; twigs and buds purple; but branches olive to nearly black-green, and smooth*

for a long time, coming off at wide angles, but not extending far. Bark fissured, with wide and more or less scaly ridges, slate-brown to nearly black. Stem continuing through to the top.

Alnus glutinosa, Gaertn. Alder (Figs. 69, 70). The twigs are purplish with angular edges, and the leaves more or less obovate. (For full description see p. 156.)

‡‡ *Trees with bright green or pale foliage, and grey-brown or reddish-brown branches and stem, whose bark shows no definite scaling of the ridges. Branches coming off at acute angles. Twigs, buds, and leaves, distichous.*

÷ *Bark on old trunks very deeply and coarsely fissured, with no decided tendency to scale; blackish-brown. Buds hairy, pointed and with several scales.*

Ulmus campestris, L. Common Elm (Fig. 97). The bark has analogies with that of Oak but is dark grey or slaty, tinged with red. At first smooth, then deeply and closely fissured, with broad furrows and narrower rather flat ridges. Corky ridges often appear very early on the branches, and in one variety they are almost winged (see also *Acer campestre* and compare *Sambucus*). Older trees have a much elongated crown. (See also p. 160.)

Ulmus montana has an ample crown with few main branches and more or less drooping spray; all the parts are more coarsely hairy, and the relative positions of seed and fruit differ. (See also p. 216.)

÷ ÷ *Fissures of the bark very shallow and fine, with broad, flat intervening ridges and no tendency*

to scale. Prevailing colour of branches reddish-brown or deep brown. Crown more or less pyramidal, the lower limbs tending to arch over and spread. Buds large,

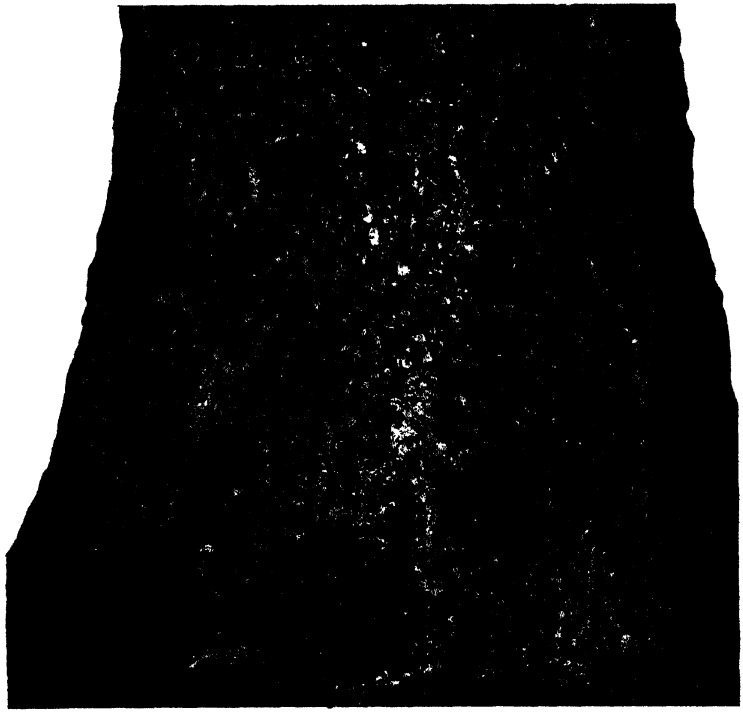


Fig. 97. *Ulmus campestris*, Common Elm. Bark (Irv).

blunt, few-scaled, glabrous. Leaves cordate and long-stalked. Flowering peduncle adherent to bract. Fruit dry.

Tilia europæa, L. Lime (Fig. 98). The fissures of the bark are very shallow, even on old trunks. The lower limbs are arcuate upwards, and the tips not upturned, the



Fig. 98. *Tilia europæa*, Lime. 1, flowering shoot; 2, fruiting shoot; 3, fruit; 4, seedling; *k*, cotyledons; 5, shoot in winter (H and W).

general shape of the crown ovoid-pyramidal to dome-shaped.

⊙⊙ *Crown not taller than broad and often widely spreading—i.e. spheroidal-depressed, broad-domed. spreading-pyramidal or spreading.*

▱ *Trunk soon breaking into the limbs, which come off at wide angles, and extend widely; the stem soon lost in the crown.* [(▱ L is not provide

§ *Evergreen with broad-pyramidal or dome-shaped, spreading crown, and dark terraced or tiered spray, composed of horizontally extended twigs bearing tufts of* 40—50 *needles. Cones large oblong.*

Cedrus Libani, Loud. Cedar of Lebanon (Fig. 6). Large tree 50—80 feet or more in height, and especially characterised by the enormous spreading branches and tabular terraced spray. These peculiarities are shared also by *C. atlantica* and *C. Deodara*, though the latter is oftener seen in the pyramidal form proper to all when young and vigorously growing (Fig. 66). (For further particulars concerning Cedars, see pp. 150—3.)

The Yew also shows a tendency to the broad crown and terraced form in old age.

The terracing observable in large Horse-chestnuts to display their broad digitate leaves in tiers should also be noted, and a few other trees show the same tendency to a greater or less extent, e.g. the Silver Firs.

§§ *Deciduous trees with extensively spreading limbs, and rounded, dome-shaped or broadly-pyramidal crowns, foliage not terraced.*

‡ *Limbs and principal branches zig-zag and tortuous, and spray very irregular, with no tendency to dichotomy.* [For (see p.

[For (÷÷) see p. 209.]

÷ *Twigs and ovoid buds aggregated towards the tips of the branches, the former in sub-verticillate tufts, the latter with scales in* 5 *ranks. General hue of branches and twigs grey-tawny to silvery-grey. Limbs few and sharply contrasted with the smaller branches, whence arises the tufted habit. Bark greyish-brown with numerous fissures. Foliage tufted, leaves lobed, oval. Fruit an acorn in a scaly cup.*

8 *Buds not fimbriated with persistent stipules; ridges of the bark broad and rugose; lobes of the leaf rounded; scales of the acorn-cup flat and closely imbricated.*

Quercus Robur, L. Oak (Figs. 46, 99, 100). Massive tree attaining 120 to 150 feet in height, and widely spreading. Foliage passing from tawny-green or olive to deep matt-green: autumn foliage tawny-brown. There are several varieties, of which var. *pedunculata* with shortly petioled leaves and long-stalked acorns, var. *sessiliflora* with nearly stalkless acorns, and var. *pubescens* with pubescent-velvety leaves and shoots, are not always readily distinguished.

8 8 *Buds fimbriated by persistent stipules; ridges of bark closer and more regular; lobes of the leaf acute; scales of the acorn long and narrow, free at the tips, giving the cup a moss-like appearance.*

Quercus Cerris, L. Turkey Oak (Fig. 101). *Quercus Cerris* may form a long pointed crown with much branched limbs.



Fig. 99. *Quercus Robur*, Oak (K).



Fig. 100. *Quercus Robur* v. *sessiliflora*, Oak (F).

Other species of Oaks more or less commonly planted are: *Q. rubra* and *Q. coccinea*, two American Red Oaks, with larger leaves that have more deeply cut and pointed, instead of rounded, lobes, with smaller buds; and with crimson autumn foliage only matched by a few other plants—e.g. the Virginian Creeper. Also the two evergreen Oaks, *Q. Ilex* and *Q. Suber*, the Holme Oak (Fig. 102) and Cork Oak (Figs. 93, 103). But these four species rarely or never attain large dimensions in this country. The Red Oaks have for a long time a smooth bark, eventually with shallow fissures, while *Q. Suber*, the Cork Oak, has deeply and roughly fissured corky bark.



Fig. 101. *Quercus Cerris* (Sc).

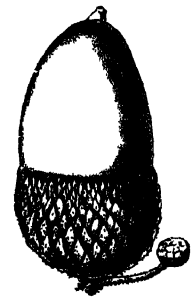


Fig. 102. *Quercus Ilex* (Kotschy).

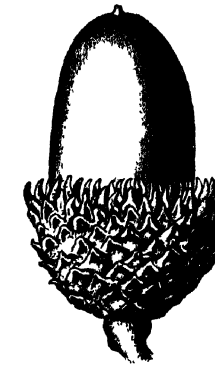


Fig. 103. *Quercus Suber* (Kotschy).

÷÷ *Twigs and buds not clustered at the tips of the branches. Buds with few scales not in 5 ranks. Twigs olive to slate-coloured or brown. Bark dark brown, coarsely fissured. Leaves not oblong and lobed; fruit not an acorn.*

General hue of twigs and branches pale olive to brown; buds distichous, leaf-scars not flanked by spines; leaves large, lanceolate, dentate-serrate; flowers small, greenish-yellow in stiff spikes; fruit brown chestnuts in prickly cupule.



Fig. 104. *Castanea vesca*, Chestnut. 1, flowering shoot; 2, vertical section through cluster of female flowers in their involucre; 3, transverse section of ovary; 4, a male flower; 5, fruits in their involucre (Wo).

Castanea vesca, L. Chestnut (Figs. 104, 105). Large

tree with considerable resemblances to the Oak in habit, but entirely different in leaves, inflorescence and fruit. Shoots tawny and pubescent, passing to olive or slate-

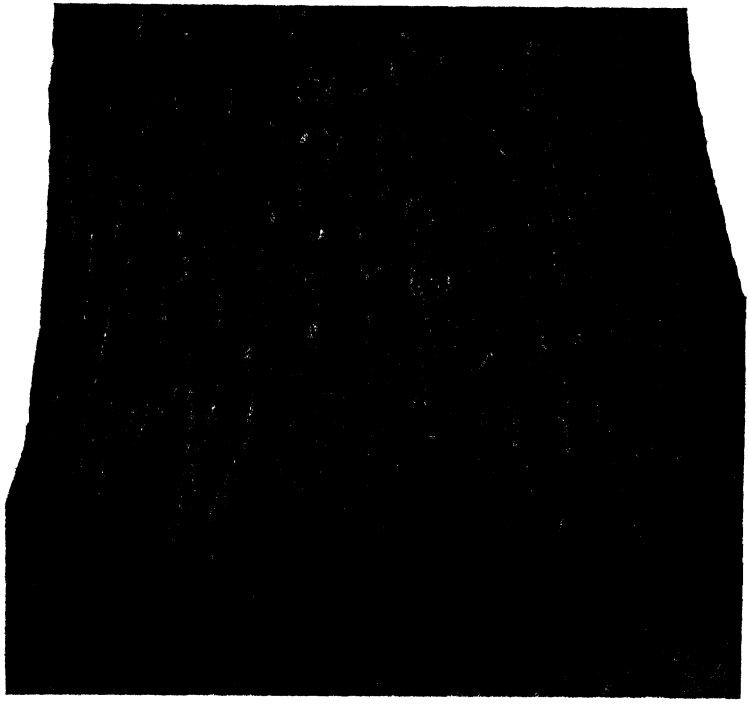


Fig. 105. *Castanea vesca*, Chestnut. Bark (Irv).

coloured twigs with conspicuous lenticels. Bark dark slate-brown, much fissured. Suckers abundant.

The Chestnut has an ample crown, in the mass resembling the Oak, but in the open very wide-spreading.

8 *General hue of twigs and branches dark slate-blackish; buds not distichous; leaf-scar generally flanked by stipular spines; leaves pinnate; flowers white, papilionaceous, in pendulous racemes. Fruit a legume.*

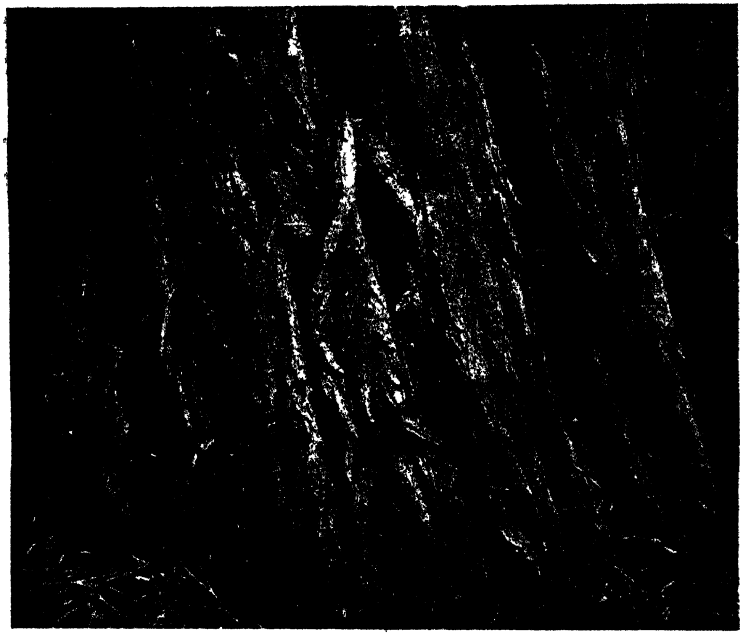


Fig. 106. *Robinia Pseud-acacia*, False Acacia. Bark (Irv).

Robinia Pseud-acacia, L. False Acacia (Fig. 106). The tree may attain 60—70 feet in height, but is usually much smaller. The dark-coloured, very widely and coarsely fissured bark, ample, spreading crown, very zig-zag spray and tortuous branches are characteristic; even more so the

flowers and fruit. Foliage very light and feathery, bright green and late. Twigs olive to shining red-brown.

Very few other trees present similarly spreading crowns and tortuous or zig-zag limbs and main branches. The Plane (*Platanus*) is at once recognised by its bark cast in large patches (see p. 175): the Walnut (*Juglans*) by its ashen- or greenish-grey bark, and thick twigs with chambered pith.

‡‡ *Limbs and branches widely extended, but not conspicuously tortuous nor zig-zag, nor as a rule coming off at very wide angles.*

÷ *Spray alternate, spiral or distichous, and showing no tendency to dichotomy.* [For (÷÷) see p. 216.]

8 *Ends of the branches ascending, and with numerous more or less erect spirally inserted twigs, forming besom-like aggregates. Buds pointed and viscid. Leaves broad, cordate. Flowers in pendent catkins. Fruits capsular; seeds minute, comose.*

Populus nigra, L. Black Poplar (Fig. 107). Large tree up to 60—70 feet in height, with a thick trunk, and abundant deeply and long-fissured blackish bark, rather like that of Oaks. Crown ovoid-conical to spreading dome-shaped. Twigs, especially those of the suckers, more or less triangular in section, with viscid pointed buds; yellow, polished, passing to greyish, with large lenticels. Branches brown-slaty. Limbs few, ascending, and but sparsely branched except towards the tips; on the branches the twigs ascend in besom-like tufts, hence the crown is loose, though the broad leaves give considerable shade in the mass.

For the fastigiate variety of the Black Poplar see p. 134.

Populus canadensis, Desf., is very similar in size and habit, but usually with a more ovoid-pyramidal crown, and the twigs and young branches apt to be ridged with corky lines, intensifying their angularity.

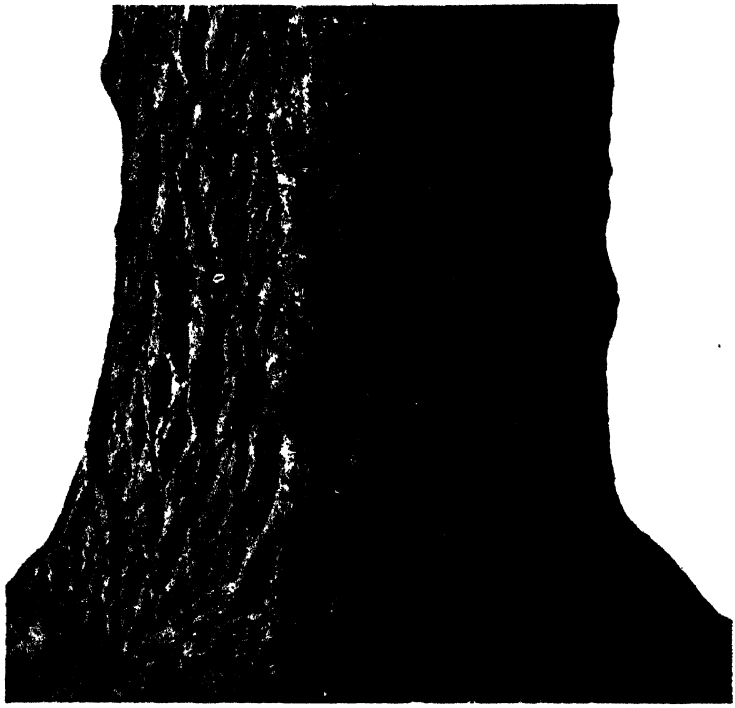


Fig. 107. *Populus nigra*, Black Poplar. Bark (Irv).

The Beech, when old, forms a widely spreading crown of somewhat similar habit, but the branches come off at smaller angles. Its buds, bark, &c., are entirely different (see p. 167).

♂ ♀ *Twigs not in tufts near the ends of ascending branches: spray distichous. Leaves broad, unequal at the base.*

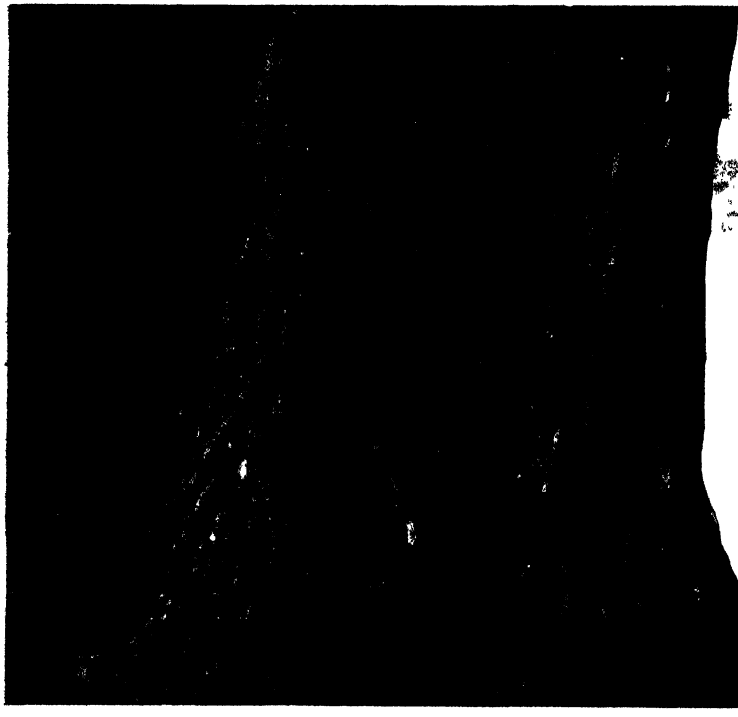


Fig. 108. *Ulmus montana*, Wych Elm. Bark (Irv).

△ *Bark deeply and coarsely fissured, deep grey-brown. Flowers very early, purple-brown. Fruit a flat oval achene, with a winged border.*

Ulmus montana, Sm. Wych Elm (Fig. 108). A large tree up to 80—100 feet in height, with more spreading habit and thicker twigs and buds than *U. campestris*, often pendent at the tips. The leaves are larger and rougher, the twigs darker coloured and deeper olive-brown, and more stiffly hairy; but the essential difference lies in the fruit, which in *U. campestris* is deeply cut at the top and the seed lies above the centre of the obovate fruit, whereas in *U. montana* the fruit is broader and more nearly orbicular, with a shallow incision, and the seed lies nearly in the centre.

△△ *Bark with very shallow fissures. Flowers late, yellowish-green, the peduncle adherent to a long bract. Fruits subglobose.*

Tilia europæa, L. Lime (Fig. 98). For further description see p. 204.

÷÷ *Spray with buds, twigs, leaf-scars and leaves opposite decussate, and tending to fork dichotomously owing to the frequent conversion of the terminal shoot to flowers.*

Acer platanoides, L. Norway Maple (Fig. 109). A tree up to 100 feet in height or more, but rarely seen so tall, with an ovoid-conic to broadly pyramidal or dome-shaped spreading crown. The deep grey bark is finely and closely fissured with shallow longitudinal, but short, furrows, and shows no tendency to scale off. The spray tends to turn up at the edges, and bears rather large olive- or reddish-green buds at the divaricating tips.

The other two species of Maple have been dealt with on pp. 180 and 185, and *A. Pseudo-Platanus* has a similar habit to *A. platanoides*. The distinctions between the



Fig. 109. *Acer platanoides*, Norway Maple. 1, flowering shoot; 2, hermaphrodite flower, after removal of calyx and corolla; 3, male flower, similarly treated; 4, ovary; 5, fruit; 6, opened fruit; 7, seed; 8, the same in section; 9, leaf; 10, buds; 11, seedling (Wi).

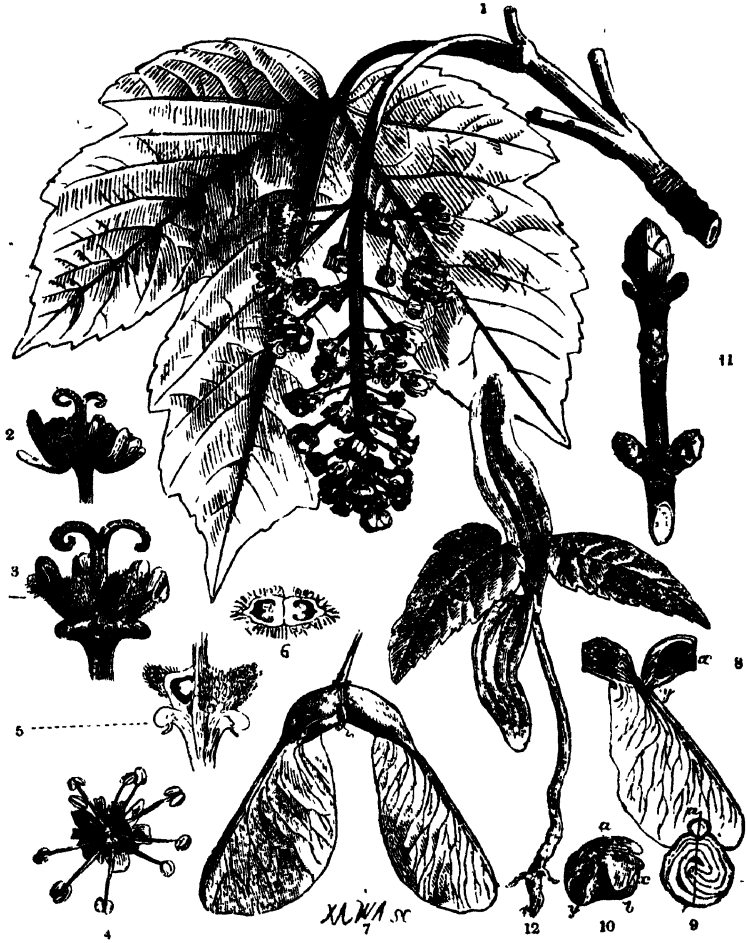


Fig. 110. *Acer Pseudo-Platanus*, Sycamore. 1, flowering shoot; 2, hermaphrodite flower; 3, the same after removal of the sepals and petals; 4, male flower seen from above; 5, ovary, with the left cell opened; 6, transverse section of ovary; 7, fruit; 8, the same opened and exposing the seed *x*, *y*; 9, seed in section across *a*, *b* in 10; 10, embryo; 11, buds; 12, seedling (Wi).

three species are as follows: *A. campestre* has much smaller, hairy (not green) buds and leaves than either of the others; its flowers are in erect corymbs, and its fruit-wings divaricating at nearly right angles with the direction of the pedicel; its bark is pale tawny, corky and fissured (see p. 185), and it has latex. *A. Pseudo-Platanus* has the flowers in pendulous racemes, no latex, the bark scaly (see p. 180) and the wings of the fruit diverging at about 45° from the direction of the pedicel; while *A. platanoides* has deep grey fissured bark, flowers in loose erect corymbs, milky latex, and the wings directed less forwards.

The greenish buds of the latter two species remind one of those of species of *Pyrus*, but in these they are alternate, whereas in *Acer* they are opposite.

II. SHRUBS OR BUSHES, WITH SEVERAL OR MANY BRANCHES FROM THE COMMON STOCK INSTEAD OF A SINGLE STEM.

(1) Evergreen parasitic epiphyte, entirely supported on other plants into which its roots penetrate.

Viscum album, L. Mistletoe. A small, rounded, yellowish-green bush, 1—3 feet high, with opposite coriaceous leaves and dichotomous branches, never rooted in soil but on various trees, of which Poplars, Lime, Apple, Pear and Hawthorn are the commonest; but also occurring on Silver Fir, Elm, Willows, Hornbeam, Beech, *Robinia*, Chestnut and *Pyrus Sorbus*. It is rarely found on Spruce, Scots Pine or other species of *Pinus*, and extremely seldom on Oak. Usually recognisable in winter by the white viscid berries. Branches smooth, green, and with no true bark.

(2) Not parasitic; always rooted in the ground.

[For (b) see p. 227.]

(a) Climbing or scrambling on other plants, and with long limp stems, which fall to the ground if removed from their support.

(α) Climbing by means of numerous short adventitious roots, put forth by the stem and closely appressed to the support. Dark evergreen glossy alternate leaves. Buds naked; bark rugged grey. Flowers yellowish-green in umbels; berries black.

Hedera Helix, L. Ivy (Fig. 48). The Ivy may climb to 30 feet or more, but is often non-climbing and prostrate or even a lax rounded shrub (see p. 253). The simple umbels and angular palmately veined and often lobed leaves are very characteristic, as is also the unpleasant odour when bruised.

(β) Climbing not by means of adherent roots, but in some other manner.

[For (**) see p. 222.]

* Twining plants, i.e. the stems or branches coil themselves round the support, usually from left to right.

[For (††) see p. 222]

† Tall twiners, with greyish bark torn into fibres on old twisted stems. Buds herbaceous and opening very early. Leaves opposite and deciduous; shoots pubescent. Flowers large and fragrant; berries red in crowded clusters.

⊙ *Cortex grey-brown and very fibrous; twigs pale yellowish or red where sunned. Leaves next the inflorescence free; flowers pink.*

Lonicera Periclymenum, L. Honeysuckle. This plant may climb up to 10—20 feet. It is common, and one of

the earliest plants of our hedges to burst into foliage. The heads of flowers usually on a long peduncle.



Fig. 111. *Lonicera Caprifolium*, Perfoliate Honeysuckle. 1, flowering shoot; 2, floral diagram; 3, ovary in vertical section; 4, cluster of fruits (Wo).

⊙⊙ *Branches smooth; twigs round, polished, yellow-brown passing to grey-brown, and fibrous. Leaves next the inflorescence connate; flowers yellow.*

Lonicera Caprifolium, L. Perfoliate Honeysuckle (Fig. 111). Of similar habit to the last. Naturalised in Cambridgeshire and elsewhere. Best distinguished by the sessile heads of flowers, closely subtended by the last pair of connate leaves.

†† Sub-shrub, occasionally coiling, but often merely flinging the branches over others: cortex not fibrous. Leaves alternate, but regularly displaced. Flowers small violet-blue; berries red.

Solanum Dulcamara, L. Bittersweet. The Bittersweet climbs to about 3—6 feet, and dies far back in winter. Twigs smooth, yellowish-grey. Inflorescence a much branched panicle and leaf-opposed. The branches may coil in either direction, or not (see p. 226).

** Not twining by the stems as a whole, but climbing by means of special organs, or merely scrambling over other plants.

[For (††) see p. 224.]

† Tendril-climbers, which twist their thin filamentous tendrils round twigs, &c., or insert the tips of such organs into crevices where they adhere.

⊙ *The tendrils are the petioles of opposite pinnate leaves, with buds in their axils. Shoots angular and silky. Flowers greenish-white. Fruits bearded with plumose styles.*

Clematis Vitalba, L. Traveller's Joy (Fig. 112). This plant may reach 20 feet and more in height. Twigs 6-angled and furrowed, olive-green or more or less purplish, smooth, or with slight pubescence at nodes. Older branches yellowish-grey, fibrous or peeling, twisted. Often recognisable in early winter by the heads of bearded achenes, and by the fact that no other British plant climbs by opposite leaf-stalks.

⊙⊙ *The tendrils are branches, leaf-opposed and themselves bearing scales, &c., but with no buds in the axils. Nodes swollen and twigs*

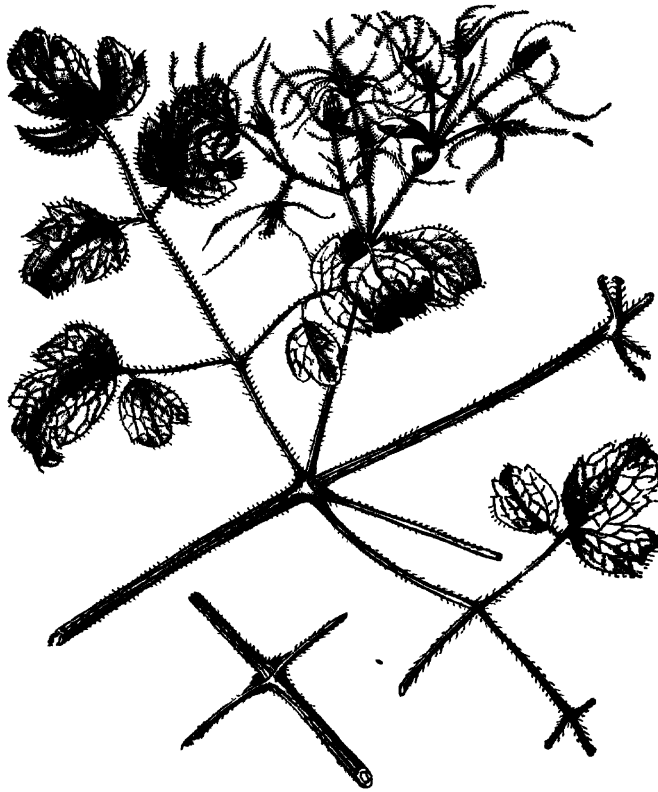


Fig. 112. *Clematis Vitalba*, Traveller's Joy (Sch).

yellowish-brown. Leaves alternate, brilliantly coloured, scarlet-purple, &c. in autumn. Flowers small green; fruits berry-like.

□ *Twigs round, with prominent lenticels: periderm of the supple and pendent branches reddish-grey, fissured and corky. Leaves compound, digitate.*

Ampelopsis hederacea, Michx. Virginiah Creeper (Fig. 50). The plant may reach the roof of a tall house, 30 feet being by no means an uncommon height. The tendrils may expand at the tips and form sucker-like discs gluing them to bricks, bark, &c. Flowers small in dense clusters, drooping in fruit, which rarely ripens in England. Twigs round, finely striate and cracked: periderm superficial, olive-tawny. The brilliant autumn foliage very striking.

□□ *Twigs striated and grooved, smooth, yellow-brown, stiff and zig-zagged: the deep periderm of older branches bursting the cortex in torn and twisted fibres. Berries (grapes) purple or yellowish.*

Vitis vinifera, L. Vine (Fig. 49). The Vine may climb up to 20—30 feet, but is rarely seen unpruned. About every third leaf is without an opposed tendril: the latter twisting only. The ragged fibrous bark is greyish.

†† No tendrils: the plant merely flings its shoots over the support, or scrambles over or through it.

[For (⊙⊙) see p. 225.]

⊙ *Scrambling by the aid of recurved prickles, flattened at the sides and broad at the base, like claws, which act as hooks preventing the shoots from slipping back. Leaves compound. Flowers rosaceous, in panicles or corymbs.*

□ *Branches angular, arching, green, or purplish. Leaves falsely ternate or digitate. Flowers in corymbose panicles. Fruit a collection of drupels.*

Rubus fruticosus, L. Blackberry. The Brambles may

send up shoots several feet long, arching, and rooting at the ends. Very many varieties exist, differing in the colour of the flowers (white or rosy) or fruit (purple or nearly black, red, &c.); the degree of armature, shape of prickles, admixture of glandular hairs, &c.; and the shapes, sizes and composition of leaves. Many forms are sub-evergreen, the leaves turning various shades of red, purple, &c. in winter, and not falling with a clean scar, so that ragged remains subtend the buds.

▱▱ *Branches terete and leaves pinnate. Flowers in corymbs, large; fruits red, tipped with sepals, &c.: so called "Hips."*

Rosa canina, L. Dog Rose. The Dog Rose also exhibits a large number of varieties, differing in the degree and kind of armature, the presence or absence of glands, &c., but all with rounded shoots and larger flowers.

Rosa arvensis with more slender and trailing branches, whiter inodorous flowers, and more globoid fruit is also common, and scrambles.

Further should be mentioned the Sweet Briar, *R. rubiginosa*; the Downy Rose, *R. villosa*, and the Burnet Rose, *R. pimpinellifolia*, often met with as non-scrambling bushes (see p. 238).

The type of prickle here met with is common to several other species of *Rubus* and *Rosa*, variations occurring in the size and strength, degree of curvature and so forth; but all are superficial outgrowths easily pushed off laterally, and some of the species do not usually climb (see pp. 237—8).

⊙⊙ *Shrubs which merely fling their long shoots over other plants.*

▱ *Twigs and branches pale grey, smooth, rounded and lax; with straight, thin, axillary spines (dwarf-shoots). Leaves lanceolate. Flowers lilac with a long tube. Fruits oblong orange-red berries.*

Lycium barbarum [so-called, but in reality *Lycium chinense*, Mill.], misnamed the "Tea Tree" (Fig. 113). Naturalised near Cambridge and elsewhere. A shrub about 4—6 feet high, formerly planted under the name of Tea Tree but with no alliance to true Tea.



Fig. 113. *Lycium chinense* (so-called *L. barbarum*). *a*, flowering shoot (½). *b*, flower. *c*, fruit. *d*, labiate calyx. *e*, five-toothed calyx (Döbner and Nobbe).

▱▱ *Sub-shrub with twigs and branches devoid of spines; leaves displaced; flowers violet-blue; berries red.*

Solanum Dulcamara, L. Bittersweet. Occasionally a partial twiner (see p. 222).

(b) Independent shrubs or bushes, not climbing on, nor supported by, other plants.

(i) Prostrate and creeping on the ground, or partially buried and rooting at the nodes. [For (ii) see p. 229.]

(*a*) *A partially buried and rooting creeper, with deep red-brown twigs, and densely silky white shoots, and lanceolate deciduous leaves. Flowers in catkins. Fruits minute capsules; seeds comose.*

Salix repens, L. Creeping Willow. The half-buried stems root at the nodes, and the erect shoots may ascend to 1—2 feet: old plants may be somewhat bushy and up to 8—10 feet. Shoots thin and hairy; branches red or purple-brown or more or less olive, yellowish, and smooth polished.

There are half-a-dozen other dwarf Willows of similar habit, belonging to the Alpine or Arctic floras, occurring as more or less rare plants in the Highlands—e.g. *S. reticulata* with more or less angular, yellow-green to pale brown polished twigs, and rounded leaves: *S. Lapponum* and *S. lanata* with the older branches terete and yellow-brown and with the shoots very silky or cottony: *S. Myrsinites*, not truly creeping but procumbent: and *S. herbacea*, the smallest British shrub, only a couple of inches or so high.

(*β*) *Prostrate, but not rooting, wiry shrub, with evergreen spine-like leaves in whorls of three, bearing small cones which ripen to blue-black glaucous fleshy "berries."*

Juniperus communis, L. Juniper [in most cases *J. communis*, var. *nana*, the Dwarf Juniper].

Juniperus communis (Fig. 114) may be a dense spreading bush 3—5 feet high, or even a small tree up

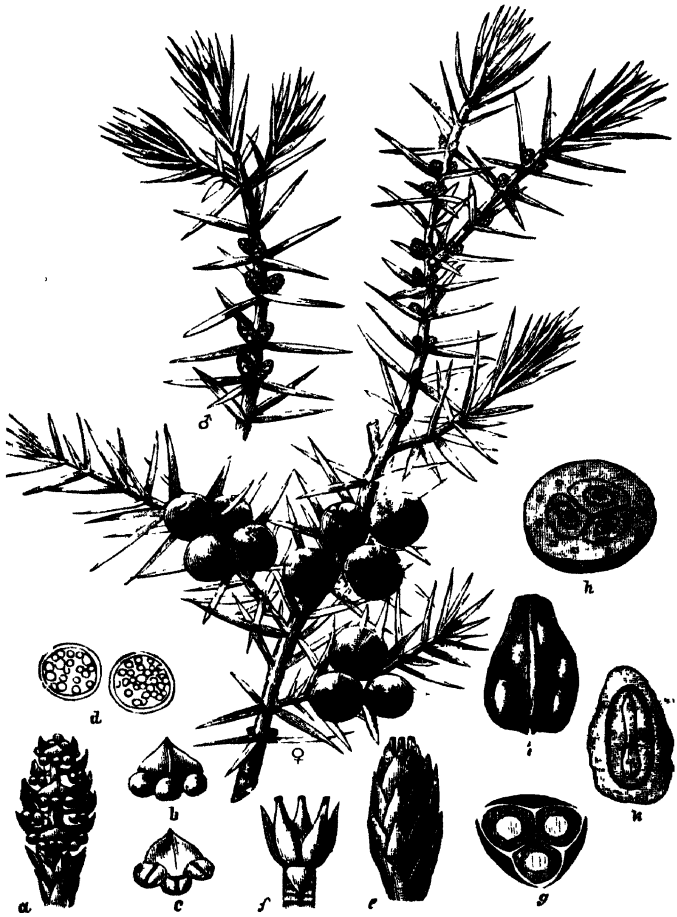


Fig. 114. *Juniperus communis*, Juniper. Shoots with ♂ and ♀ flowers. *a*, a ♂ flower; *b* and *c*, stamen seen from above and from below; *d*, pollen; *e*, a ♀ flower; *f*, the three ovules with the subtending carpellary scales; *g*, transverse section of the same; *h*, the "berry" (*galbulus*) in section; *i*, seed; *k*, the same in section (B and S).

to 15—20 feet. The so-called "berries" are due to the cone-scales becoming fleshy (see Vol. IV).

The rare *Genista pilosa* and *Cotoneaster vulgaris* also occur as prostrate plants; the former with fine wiry twigs and yellow papilionaceous flowers, the latter with white cottony shoots and lower leaf-surfaces, dark red twigs, and small white rosaceous flowers.

The Ivy also grows closely prostrate in woods, in a non-flowering form and often with very different leaves from those on the climbing form.

Betula nana should also be noted as more or less prostrate (see p. 249).

(ii) Erect shrubs or bushes, neither climbing nor prostrate.

(*a*) *Branches or leaves armed with spines, thorns, or prickles.* [For (β) see p. 238.]

* The spines are true thorns, i.e. axillary dwarf-shoots, which may bear buds or leaves, but have no buds in their axils. [For (**) see p. 234.]

† Small bushes about 1—5 feet high, densely branched and tufted. Leaves minute or absent. Flowers yellow and papilionaceous; fruit a small legume. [For (††) see p. 231.]

▱ *Evergreen bush, 2—5 feet high, apparently leafless; the leaves of older plants being reduced to spines, with branched thorns—i.e. dwarf-shoots—in their axils. Twigs and branches green and striate furrowed. Older stems with tawny-grey, fissured, corky bark. Flowers rather large, solitary. Legumes black, with brown hairs. Seeds olive.*

Ulex europæus, L. Gorse (Fig. 115). *U. nanus*, the Dwarf Furze, is smaller, 1—3 feet, more densely tufted,

and has more slender spines and deeper orange-yellow flowers.

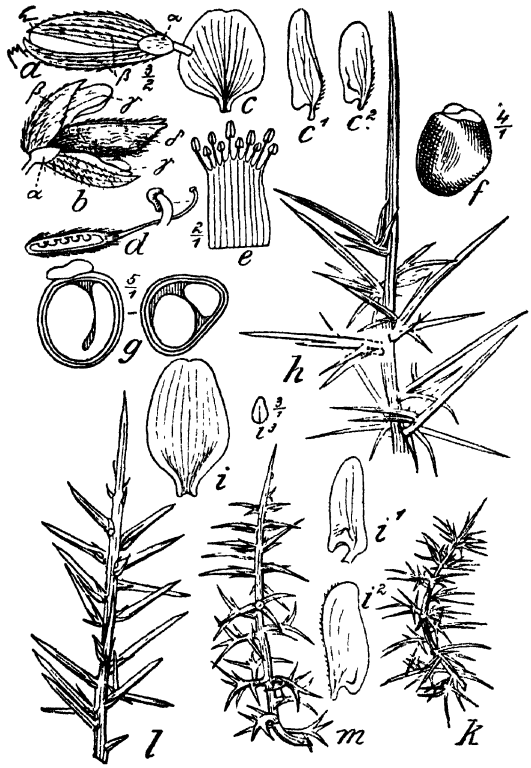


Fig. 115. *Ulex*. *a*—*h*, *U. europæus*: *a*, flower (*α* = bracteole, *β* = calyx); *b*, fruit (*γ* = corolla, *δ* = pod); *c*—*c*², standard, wing, and keel; *d*, pistil in longitudinal section, and magnified stigma; *e*, androecium opened out; *f*, seed; *g*, longitudinal and transverse sections of seed; *h*, branch; *i*—*k*, *U. nanus*: *i*—*i*² = *c*—*c*²; *i*³, bracteole; *k*, branch; *l*, *U. parviflorus*, branch; *m*, *U. welwitschianus*, branch. (After Schneider.)

▱▱ *Bush 1—2 feet high. Leaves minute; spines reflexed slender; bark brown and membranous. Flowers in short leafy racemes; pod brown with black seeds.*

Genista anglica, L. Needle Furze. *G. tinctoria*, a small irregular, erect bush about 1—3 feet, has green smooth striate angular shoots. The stipules are sharp and cover the bud, but it can scarcely be called spinescent.

Lycium chinense also comes here in regard to its thorns (see p. 226).

†† Taller shrubs from 8—10 up to 20—30 feet high, with more woody and thicker branches, and with much stouter, woody and dark coloured thorns.

⊙ *Shoots, buds, and leaves ferruginous—or silvery—bronzed; leaves linear-oblong; buds obovoid, lobed. Periderm brown; bark thick, fissured, scaly, and fibrous. Flowers small yellowish-green, dioecious; fruit sub-globose, fleshy, orange-yellow, spotted.*

Hippophaë rhamnoides, L. Sea Buckthorn (Fig. 116). A shrub or almost a small tree up to 15 feet in height or more, with numerous suckers, and densely branched. Twigs silvery or golden with bright scales, and bearing old-gold bronzed buds. Branches, with thorny dwarf-shoots, smooth dark red-brown. Bark dark brown, peeling.

⊙⊙ *Shoots and buds not bronzed; leaves broad and toothed or cut; buds pointed. Bark dark coloured, purple-brown to blackish. Fruits not orange nor spotted.*

▱ *Buds, twigs, leaf-scars and leaves sub-opposite. Twigs polished, round, red-brown to nearly black; periderm peeling; bark fissured. Flowers greenish, small. Berries black.*

Rhamnus catharticus, L. Buckthorn. An erect, stiffly branched shrub, or even a small irregular bushy tree up to 20 feet in height, the stem curved and buttressed;



Fig. 116. *Hippophaë rhamnoides*, Sea Buckthorn. Fruiting branches (Sc).

bark nearly black, fissured; buds deep brown. Dwarf-shoots bearing buds and often ending in a thorn. Leaves

ovate, serratulate. The best distinction from *Prunus spinosa* lies in the paler epidermis, more prominent, scattered lenticels, the polygamo-dicœcious flowers and their structure, and the curved venation of the leaves, which are sub-opposite.

▱▱ *Twigs, buds, leaf-scars and leaves alternate; shoots hairy, more or less angular; twigs dark brown-red to glistening black. Venation pinnate. Flowers white or pink, rosaceous.*

§ *Twigs dark brown-red to pale brown, passing to glistening black often filmed with grey. Leaves ovate, serrulate. Flowers small tufted and very early. Fruits blue-black with waxy bloom.*

Prunus spinosa, L. Blackthorn (Fig. 10). A shrub 8—10 feet high, very stiffly branched, and dark, almost black, in hue, showing up the clustered flowers in early spring. The twigs may vary to paler brown, and the branches may have a silvery-grey film as the epidermis peels.

Prunus insititia is a variety with browner branches, fewer spines, and with fruit varying to yellow in colour.

§§ *Twigs olive-green to red-brown or purplish, passing to grey or blackish-grey and fissured on the branches. Leaves angular, lobed. Flowers in corymbs, white or pinkish. Fruit oblong, red, tipped with remains of the calyx, &c.*

Cratægus Oxyacantha, L. Hawthorn (Fig. 117). It is frequently met with as a shrub, and would then come here: we have dealt with it as a small tree (see p. 199). Its dense and stiffly branched, and usually very thorny habit; the olive-green to red-brown or purplish branches—sometimes with dashes of bright yellow; the older stems grey to

blackish-grey, with fissured-scaly bark, and thorns 10—20 mm. long, stout, sharp, and bearing buds, are all noteworthy. The leaves are lobed, the flowers white or pink and characteristically scented; and the red fruit with remains of calyx above serve to distinguish it.



Fig. 117. *Cratægus Oxyacantha*, Hawthorn. 1, flowering shoot; 2, fruit; 3, section across latter (Wo).

These typically thorny shrubs, *Prunus spinosa*, *Rhamnus catharticus*, and *Cratægus Oxyacantha* are apt to be without thorns, in which case they come under another section (see p. 259).

** The spines are not true thorns—i.e. not axillary dwarf-shoots, bearing buds, &c.—

as is proved by their being either irregularly scattered on the internodes or leaves or themselves having buds in their axils.



Fig. 118. *Ribes Grossularia*, Gooseberry (D).

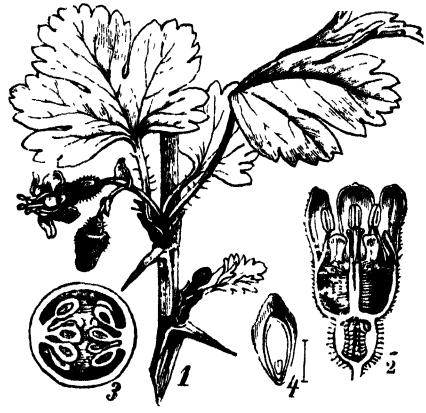


Fig. 119. *Ribes Grossularia*, Gooseberry. 1, flowering shoot; 2, flower in vertical section, enlarged; 3, transverse section of fruit; 4, vertical section of seed (Wo).

† Spines triple or quintuple, with buds or dwarf-shoots in their axils. Small bushy [For (††) see p. 236.]

shrubs 3—6 feet high, with simple deciduous leaves.

⊙ *Spines pulvinar, usually triple, hiding the leaf-scar: twigs whitish-grey with dark hairs, passing to grey-brown: not yellow inside. Flowers in pairs or single, greenish. Fruit a berry capped by calyx, &c.*

Ribes Grossularia, L. Gooseberry (Figs. 118, 119). A densely branched bush 1—3 feet high. Branches with greyish peeling periderm. Spines stiff, in some cases single and scattered on the internodes as well. Leaves lobed, pubescent, fascicled on dwarf-shoots. Buds pointed.

⊙⊙ *Spines—really leaves reduced to spines—quintuple or triple, somewhat reflexed and pale-brown. Branches whitish or brownish-grey, passing to fissured pale brown. Leaves obovate, toothed, smooth. Flowers yellow, in pendent racemes; berries oblong red.*

Berberis vulgaris, L. Barberry. Bushy shrub 4—6 feet high, or sometimes almost a small tree attaining 8—10 feet, with long over-hanging branches marked with fine long fissures. Often somewhat tufted, or losing all character in hedges. Wood brilliant yellow. Fruit acid. Buds obtuse. The spines may be occasionally single or divided into seven.

†† Spines not pulvinar nor representing leaves, neither with buds nor shoots in the axils, and neither triple nor branched.

[For (⊙⊙) see p. 237.]

⊙ *Spines on the margins of true leaves, as spinescent teeth, or themselves subulate leaves. Evergreen shrubs.*

▱ *Spines on the margins of the leaflets of a pinnate glossy leaf.*

Berberis Aquifolium, Pursh. Mahonia. Evergreen bush about 3—4 feet high, in all essentials except the

leaves as in Barberry, but berries blue-black with waxy bloom. The twigs deep shining green.

The Holly is often met with as a bush, and in that case comes here on account of its spinose-toothed glossy evergreen leaves (see p. 155).

▱▱ *Spinose subulate glaucous leaves in whorls of three. Flowers as small cones, becoming fleshy, blue-black "berries."*

Juniperus communis, L. Juniper. Already dealt with as a straggling shrub (see p. 227).

Mention may here be made of the curious little sub-shrubby Monocotyledon, *Ruscus aculeatus*, L., the Butcher's Broom, occasionally found under hedges. It is 1—2 feet high, and has rigid flat spinescent branches (cladodes) bearing scales and flowers on the face, and springing from the axils of scales—reduced leaves.

⊙⊙ *The armature consists of superficial prickles scattered on the internodes, midribs, &c., and neither axillary nor themselves bearing buds, &c. in their axils. Flowers rosaceous.*

▱ *Twigs long and ascending, with waxy bloom, and straight or curved prickles. Leaves 3—5-foliolate, white hoary beneath. Fruit a collection of drupels.*

Rubus Idæus, L. Raspberry. A bush, 2—5 feet in height; the ascending twigs at length overhanging, smooth, round, and with very slender prickles and glandular hairs, often twisted and finely striate, pale yellowish to brownish or olive. Some branches with curved prickles, others with straight ones only.

▱▱ *Twigs devoid of waxy bloom. Leaves pinnate, and not hoary beneath. Fruit ovoid or urceolate, red, with remains of calyx, &c. at the tip.*

§ *Small bush with very glandular-haired and sweet-scented foliage; prickles curved and claw-like, mixed with bristles. Fruit smooth ovoid.*

Rosa rubiginosa, L. Sweetbriar. The Sweetbriar may be 6 feet or so high, but often is smaller, bushy, with elongated stout shoots. The prickles tend to be paired beneath the leaf-scars, irregularly scattered elsewhere. Flowers pink. The plant may scramble (see p. 225).

§§ *Foliage not scented. Prickles mostly very slender and straight.*

‡ *Very small shrub, a foot high, with unequal prickles, very small simply toothed leaflets, and nearly black fruit.*

Rosa pimpinellifolia, L. Burnet Rose. An erect, densely branched shrub with small white or pink flowers; usually near the sea.

‡‡ *Larger bush, with downy doubly serrate leaves, and globoid prickly red fruit.*

Rosa villosa, L. Downy Rose. The Downy Rose is allied to *R. canina*, but is a more independent bush, distinguished by the above characters. The more scrambling roses, *R. canina* and *R. arvensis*, have been dealt with on p. 225.

(β) *Bushes or shrubs with no armature of prickles or thorns of any kind.*

[For (**) see p. 247.]

* Twigs, buds, leaf-scars and leaves opposite.

[For (††) see p. 242.]

† Bushy or tufted, much branched shrubs, not suitable for switches, withes or wands.

(That is to say, a boy on the look out for a long, thin, tough and elastic, or "whippy" switch, or a straight rigid wand, would pass over such shrubs in favour of others

which follow, because he would have to cut off too many lateral twigs or branches to obtain a suitable weapon.)



Fig. 120. *Euonymus europæus*, Spindle Tree. 1, flowering shoot; 2, 3, flowers from above and below; 4, fruit; 5, the same in section; 6—8, seed whole and in section (Wi).

⊙ *Twigs more or less 4-angular, owing to as many slender ridges running down the internodes, olive-green to brownish; branches grey-brown or reddish, with 4 corky ridges. Leaves oblong acute. Flowers small, greenish. Fruit 4-angular, with orange aril to the seeds.*



Fig. 121. *Aucuba japonica*, Aucuba. *A*, shoot bearing male flowers; *B*, a male flower magnified; *C*, an inflorescence of female flowers; *D*, a female flower magnified; *E*, ovary, and *F*, fruit in longitudinal section (E and P).

Euonymus europæus, L. Spindle Tree (Fig. 120). A stiffly branched shrub or nearly a tree up to 10—15 feet in height. Dark green, with the rounded 4-ridged branches apt to be bent. The curious quadrilateral capsules resemble a priest's cap, and the orange seeds gleam brightly in their setting.

⊙⊙ *Twigs and branches not 4-angular or ridged; leaves not oblong-acute. Flowers*

not green. Fruit not capsular, and seeds not arillate.

▱ *Evergreen shrub, with large and glossy, broadly lanceolate leaves; flowers purple-brown, small diœcious; berries red.*

Aucuba japonica, Thunb. Aucuba (Fig. 121). A loosely branched, densely foliaged shrub [often] about 3—4 feet high [or taller]. Leaves often variegated with white



Fig. 122. *Cornus sanguinea*, Dogwood. Flowering shoot (Wi).

[or yellow]. One of the plants popularly termed "Laurels" by gardeners, but see p. 253. The leaves are coriaceous and opposite.

□□ *Deciduous bush with dirty grey, slightly pubescent twigs, small thin oval leaves, yellow flowers, connate in pairs, and crimson berries.*

Lonicera Xylosteum, L. Fly Honeysuckle. A stiffly branched erect bush, about 5—7 feet high, with the bark of the greyish branches and stems peeling or torn and fibrous. The other two species of *Lonicera* are twiners (see pp, 220—2).

†† Loosely or sparsely branched shrubs, with long erect wand-like or switch-like withy twigs, often as suckers.

⊙ *Long twigs blood-red, polished, passing to red-brown or olive; leaves oval with curved veins, crimson in autumn; flowers small, white, in crowded corymbs; berries black.*

Cornus sanguinea, L. Dogwood (Fig. 122). Shrub attaining 10—15 feet in height, with olive-brown older branches showing long fine fissures and rough lenticels. The blackberries remain on late, and the intense colour of the winter twigs, the hue of arterial or venous blood, renders the plant unmistakable.

⊙⊙ *Twigs and autumn leaves not bright red, and venation not curved.*

□ *Suckers and long wand-like twigs thick, often slightly angular, smooth, grey or yellowish, with much pith, and large dark corky lenticels. Bark tawny-grey, rugged and corky. Leaves pinnate. Flowers white. Berries black-purple.*

Sambucus nigra, L. Elder. Shrubby, or a small tree up to 30 feet high (see p. 183) with a peculiar odour when bruised. Stems irregular, and branches tending to bend over and send up long, erect, wand-like twigs. Leaf-scars large; buds opening early, and ragged.

Acer campestre and *Ulmus campestris* are often shrubby in hedges, &c., and have a great tendency to form tawny-grey corky periderm, which is ridged and furrowed on the branches: it is less rugged than that of *Sambucus*, but there are certain resemblances. Both are much more woody and stiffly branched; and the buds, leaves, flowers and fruit differ entirely (see pp. 160, 185).

▱▱ *Twigs not thick nor pithy; leaves not compound, and lenticels not prominent.*

§ *Twigs greyish or whitish, mealy; buds naked; leaves large oval, grey-green, hairy; flowers white in dense corymbs; fruit fleshy, flattened, red to black.*

Viburnum Lantana, L. Wayfaring Tree. An erect shrub, common on chalk, 10—15 feet, abundantly but loosely branched. Twigs more or less angular at tips, and nearly white with grey, scurfy, stellate hairs. Branches yellowish-brown, passing to grey-brown, with long fissures. The flattened oval fruits, mealy shoots and foliage, and the naked elongated buds are very characteristic.

§§ *Twigs and foliage not mealy; buds not naked; and fruit not flattened.*

‡ *Shoots slightly angular; twigs shining pale-brown or grey; leaves lobed and with glands on their petioles. Flowers in dense cymes; the outer ones much larger, barren and white. Fruit scarlet.*

Viburnum Opulus, L. Guelder Rose (Fig. 123). A shrub or small tree, up to 10—12 feet high, easily recognised by its glandular petioles, broad lobed leaves, and the larger white barren flowers at the edges of the umbellate cymes. Bark yellowish grey, fissured; branches weak, tawny-grey. Suckers long and wand-like. The buds exhibit at most two scales on the outside.



Fig. 123. *Viburnum Opulus*, Guelder Rose. 1, flowering shoot; 2, a barren, and 3, a hermaphrodite flower; 4, portion of fruiting cyme; 5 and 6, kernel in vertical and transverse section (Wi).

‡‡ *Shoots and twigs round, smooth, more or less grey; buds with several visible scales; leaves not lobed; flowers not of two kinds, and fruit not red.*

÷ *Twigs ending in a pair of rather large olive-green or brownish buds; branches grey. Leaves more or less cordate, on long petioles. Flowers lilac, in pyramidal inflorescences Fruit a capsule.*

Syringa vulgaris, L. Lilac (Fig. 12). A shrub or small bushy tree, 10—15 feet high, with a besom-like habit, sending up numerous erect, round, yellowish-grey or olive twigs with conspicuous lenticels, and often forked in a pseudo-dichotomous manner. Bark grey to grey-brown, fissured and scaly.

Olive-green buds, with greenish scales edged with brown, are met with in several species of *Pyrus* (pp. 196—7) and *Acer* (p. 219). The former are distinguished at once by the scales being spirally inserted, but in *Acer* they are opposite and decussate as here. With plants in leaf and flower there is no difficulty: in the winter state the periderm and bark are diagnostic, but a sharp mark of recognition is also found in the leaf-scars, which in *Acer* have three, in *Syringa* only one elongated leaf-trace bundle. Moreover *Acer* has a terminal bud.

÷÷ *Buds not paired at the end of the twigs; leaves not cordate nor long-stalked; flowers if lilac not in bunches; and fruit not capsular.*

8 *Twigs shedding fine silky cortical fibres, pale grey to yellowish, thin. Leaves glaucous beneath. Flowers rosy, few, in the leaf axils. Berries white.*

Symphoricarpos racemosus, Mchx. Snowberry (Fig. 124). A small bush, 3—6 feet [or more] high, with



Fig. 124. *Symphoricarpos racemosus*, Snowberry. *a*, flowering shoot ($\frac{1}{3}$); *b*, flower with corolla opened; *c*, unripe fruit; *d*, ripe fruit (Döbner and Nobbe).

switch-like, smooth pale greyish or yellowish twigs passing to brownish-grey branches, from which the cortex is shed in silky fibres. Leaves broadly lanceolate. The snow-white berries often remain far into the winter, and are much larger than those of Mistletoe. Suckers abundant.

8 8 *Twigs not shedding silky fibres, slightly pubescent at tips, olive-grey to brownish. Leaves not glaucous. Flowers white in small panicles. Berries black.*

Ligustrum vulgare, L. Privet. An erect, much branched shrub, 10—15 feet high. Branches grey, with rather conspicuous lenticels. Dwarf-shoots often in whorls of three or more. Flowers unpleasantly odorous. Leaves more or less lanceolate and may remain on through the winter (sub-evergreen).

** Twigs, buds, leaf-scars and leaves alternate.

† Bushy or tufted, usually much branched shrubs, not suitable for supplying switches, withes or wands (see p. 238). [For (††) see p. 259.

For bushy shrubs with spines, thorns or other armature, see pp. 229—38.

⊙ *Small lax evergreen, with rosettes of glossy, dark green leathery leaves, in tufts at the ends of the few flexuous, very supple, and tough branches. Cortex yellow-grey and corky. Flowers small, green. Berries blue-black.*

Daphne Laureola, L. Spurge Laurel. About 2—4 feet high, very sparsely branched; the corky and peculiarly supple and tough twigs marked with transverse wrinkled leaf-scars, mostly with aborted buds.

⊙⊙ *Deciduous shrubs, not remarkable for supple or tough corky branches.*

[For (□□) see p. 253.]
[For (§§) see p. 249.]

□ *Small bushes rarely over 1—5 feet high.*

§ *Foliage, shoots and cortex, with more or less pronounced odour on rubbing or bruising, in part due to glandular hairs.*

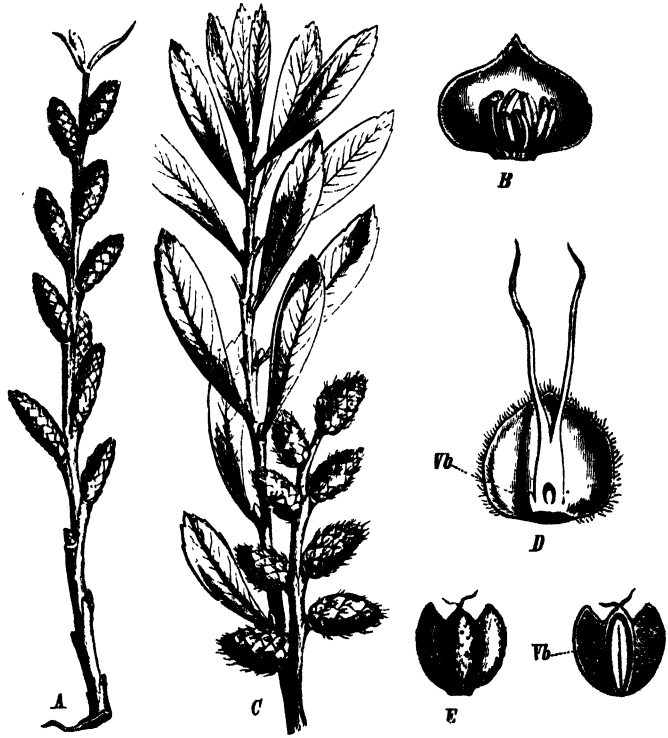


Fig. 125. *Myrica Gale*, Bog Myrtle. *A*, shoot with ♂, and *C*, with ♀ catkins; *B*, scale with ♂ flower; *D*, scale with ♀ flower, the latter in section; *E*, fruit with its two fused lateral bracteoles; *F*, the same in section (E and P).

‡ *Odour resinous, fragrant. Twigs red-brown, or yellowish, passing to-*

blackish-brown, glabrous. Leaves narrow. Flowers in catkins. Fruit minute, resinous.

Myrica Gale, L. Bog Myrtle (Fig. 125). Small erect densely branched bog bush, 2—3 feet high, with brittle twigs and branches, not peeling, but at length finely fissured. Leaves more or less oblong. The odour is due to resinous glandular hairs.

‡‡ *Odour unpleasant. Twigs grey, with peeling epidermis, and slightly pubescent at tips. Leaves broad, lobed. Flowers in pendent racemes; fruit a berry, black.*

Ribes nigrum, L. Black Currant. Bush up to 5—6 feet high. Twigs and buds studded with yellow glandular hairs; twigs stiff and brittle. Not bog-plants. Leaves palmatifid.

Daphne Mezereum also emits a somewhat unpleasant odour when crushed, but not to a pronounced extent (see p. 251).

§§ *Foliage and shoots not markedly nor peculiarly odorous on rubbing.*

‡ *Twigs dark in colour, red-brown to deep purplish-brown. Low or slightly erect bushes.* [For (‡‡) see p. 250.

÷ *Small bush with very slender, deep brown twigs and branches, slightly peeling as in the Birch. Leaves rotund, dark green. Flowers in catkins. Fruits seed-like, winged.*

Betula nana, L. Dwarf Birch. A rare plant of the Scottish Highlands, from a few inches to 3 feet high. Older branches slightly fissured. Dwarf-shoots ringed with leaf-scars. Shoots pubescent, but leaves glabrous and petiolate (see p. 229).

÷÷ *Twigs bright red-brown, pubescent at tips. Leaves broad oval, white-tomentose beneath, and nearly sessile. Flowers pink, rosaceous. Fruit berry-like, red.*



Fig. 126. *Daphne Mezereum*, Mezereon. 1, flowering shoot; 2, vertical section of flower enlarged; 3, fruiting branch (Wo).

Cotoneaster vulgaris, L. Cotoneaster. A more or less procumbent, rare shrub up to 6 feet in height. Shoots soon become smooth, round, polished, and pass through shades of olive to brown, or silvery grey-green.

‡‡ *Twigs and branches pale in colour, greenish-grey to yellowish-grey.*

÷ *Leaves aggregated at the ends of the few shoots, lanceolate; branches loose.* [For (÷÷) see p. 252.]

8 *Small, loosely branched, besom-like bush, with smooth yellowish twigs and corky branches. Leaves glabrous. Flowers small, pink, appearing before the leaves; berries red.*



Fig. 127. *Salix aurita*, Eared Willow (Sw).

Daphne Mezereum, L. Mezereon (Fig. 126). About 1—3 feet high; twigs smooth, yellow or tawny, passing to brown-grey branches with corky easily tearing periderm. Tissues slightly malodorous on bruising. Branches supple and very tough.

8 8 *Shrub with pale brown to grey peeling branches, sub-verticillate. Leaves hairy. Flowers large, yellow, fragrant. Fruit capsular.*

Azalea pontica, L. Azalea. An erect shrub about 3—6 feet high, with stiff smooth tawny twigs. Periderm grey and peeling in laminæ. Flowers clammy and strongly scented.

÷ ÷ *Shoots numerous and leaves not tufted or lanceolate.*

8 *Shoots grey, velvety, twigs reddish; leaves obovate, much wrinkled, stipules large. Flowers in catkins; fruits capsular and seeds comose.*

Salix aurita, L. Eared Willow (Fig. 127). Bushy, about 3—5 feet high, with brown buds on the thin twigs. Buds with one scale only.

S. Caprea and the variety *cinerea* pass so gradually into this, that great difficulties may be met with. The former is usually a taller shrub, with larger and more elliptic leaves and smaller stipules; the latter more tomentose. All have the wrinkled leaves.

For other bushy Willows see pp. 255—7, 263—8.

8 8 *Shoots not velvety; twigs pale grey. Leaves broad, angular and lobed. Flowers in pendent racemes; berries red.*

Ribes rubrum, L. Red Currant. Bushy shrub about 3—6 feet high, with stiff twigs, at most pubescent at tips. Twigs pale grey with traces of 4 ridges; buds with several scales. Branches ashy-grey with peeling periderm, passing to blackish-grey. Odorous on crushing, but not strong and unpleasant as in Black Currant.

The small glabrous Alpine Currant, *R. alpinum*, L., with yellowish flowers and red fruit is too rare to be more than mentioned. *R. aureum*, with yellow flowers, and *R. sanguineum* with red flowers are cultivated.

Solanum Dulcamara (p. 222) may come under this heading of small bushes, with alternate leaves and pale twigs.

▱▱ *Large shrubs* 10—20 *feet or more in height.*

§ *Evergreens, with large glossy lanceolate leaves; rosaceous flowers in racemes, and purple-black drupes.* [For (§§) see p. 254.

‡ *Twigs purple to purple-black; [base of the leaf-blade] not glandular.*

Prunus lusitanica, Lois. Portugal Laurel. Dense rounded shrub up to 10—12 feet high.

‡‡ *Twigs green; [leaf-blade] with* 2—4 *glandular [patches on the lower face].*

Prunus Laurocerasus, Lois. Cherry Laurel. A rounded shrub 6—20 feet high. The crushed leaves have a faint smell of bitter almonds.

The name Laurel, commonly given by gardeners to these species of *Prunus* and to *Aucuba japonica* (see p. 241), is properly applied to the Bay, *Laurus nobilis*, a very different evergreen shrub, occasionally seen in gardens, the leaves of which are alternate, lanceolate, and fragrant.

The Privet, *Ligustrum vulgare*, so frequently retains many of its leaves through the winter, that it may be regarded as sub-evergreen (see p. 247).

The Ivy is sometimes seen as a rounded shrub, neither climbing nor prostrate.

Here also, as regards size and general habit, may be placed *Arbutus Unedo*, L., the Strawberry Tree, the leaves

of which are lanceolate, leathery, dark green above and paler beneath. It is a large shrub or small bushy tree, 10—15 feet or so in height, with red-brown branches, and a finely fissured [but ultimately remarkably smooth] stem. The fruits present a peculiar superficial resemblance to Strawberries, in colour, texture and warted surface, but are totally different in structure.

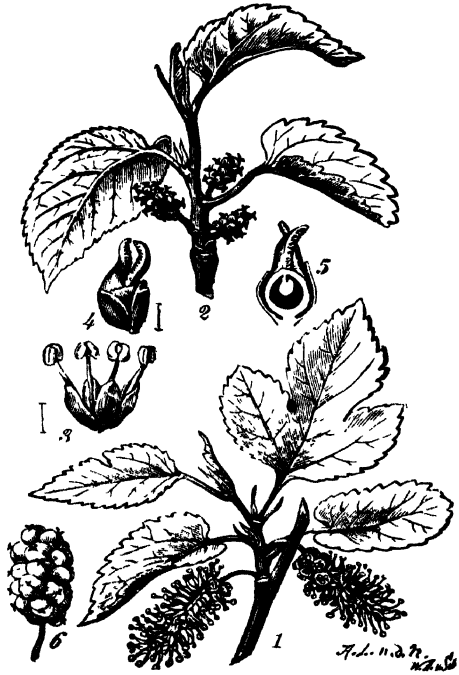


Fig. 128. *Morus alba*, Mulberry. 1, a male, and 2, a female flowering shoot; 3, male, and 4, female flower, enlarged; 5, the latter in vertical section; 6, the multiple fruit (Wo).

§§ *Not evergreen; leaves neither shining, coriaceous, nor lanceolate.*

‡ *Shoots and leaves abounding in white latex. Twigs greyish to brown. Leaves variable, some lobed. Flowers small and crowded, unisexual. Fruits compound, fleshy.*

Morus alba, L. Mulberry (Fig. 126). Shrub, or stunted tree, up to 30 feet, and apt to form suckers. The stiffly branched crown is often due to pollarding. Twigs more or less hairy at tips, otherwise smooth, shining and rounded. Older branches grey-brown and finely fissured.

M. nigra, the Black Mulberry, has stouter and smoother twigs and branches, polished olive to yellowish grey-brown, and generally darker hued to blackish-grey. Twigs more angular, and may be a tree up to 30—40 feet or so.

Rhus typhina, a loosely branched shrub, or bushy tree, up to 20 feet or so, with olive-brown densely hairy shoots, becoming smooth and shining with prominent lenticels, may also be placed here. The leaves are pinnate, and richly coloured red, purple, &c., in autumn; the twigs stout and blunt, and suckers abound. The older shrubs are usually recognisable by the long persistent cylindroid heads of densely crowded and hairy, purple infructescences.

‡‡ *Shrubs devoid of latex. Twigs and branches of dark colours, brown, &c. Fruits not compound.*

÷ *Buds showing one true scale only. Flowers in erect catkins. Fruits capsular; seeds comose. Shrubby Willows.* [For (÷÷) see p. 257.]

8 *Leaves broad, more or less ovate, and wrinkled, dark green above, tomentose beneath. Twigs on the whole pale olive, &c.*

Salix Caprea, L. Sallow (Fig. 129). A bushy or large silvery shrub, 3—10 feet high, or a small tree up to 30 feet



Fig. 129. *Salix Caprea*, Sallow. 1, apex of twig with ♂ catkins; 2, a ♂ flower; 3, base of same, showing gland of scale; 4, end of shoot with a ♀ catkin; 5, a ♀ flower; 6, stigma; 7 and 8, capsule closed and open; 9, seed; 10 and 11, buds; 12, leafy shoot (Wi).

or so, and very variable. The under-sides of the leaves are tomentose, with rather broad stipules. It flowers very early in spring. Buds usually smooth and yellow or tawny; the flowering buds very large. The variety *cinerea*, however, is tomentose throughout and the distinctions between these two and *S. aurita* are critical (see p. 252). Twigs yellowish or olive to dark brown; shoots grey-tomentose. Old bark coarsely fissured.

8 8 *Leaves narrower, more or less lanceolate, not conspicuously wrinkled. Twigs on the whole brown.*

Salix nigricans, Sm. Black Willow. Large bushy shrub 10—12 feet high, with more or less ovate, not wrinkled, glabrous leaves, which are glaucous beneath. Stipules large. Shoots grey-tomentose, passing to chestnut-brown or reddish-olive branches, and retaining their hairy covering for some time. Buds hairy and reddish.

The critical distinctions from the usually more glabrous *S. phylicifolia*, L., the Tea-leafed Willow, cannot be dealt with here. Both are extremely variable, and pass towards *S. Caprea* and *S. Myrsinites*.

Here also may be placed the more bushy forms of *S. daphnoides*, easily recognised by the white waxy bloom on its plum-purple to nearly black, smooth, older twigs; *S. triandra* and *S. pentandra* with three and five stamens each instead of two, the common number for our Willows; also *S. purpurea* with one stamen (really two fused into one), the distinctive characters of which are founded on critical points apart from habit.

÷ ÷ *Buds not with a single scale; flowers not in catkins; fruits not capsular and seeds not comose. Dwarf-shoots conspicuous as nodulose "spurs," ringed by leaf-scars.*

Leaf-scars narrow, band-like, and extending far round the twig. Leaves ovate, hoary beneath, as are the twigs. Flowers pink, large, rosaceous; fruit a pome.



Fig. 130. *Rhamnus Frangula*, Alder Buckthorn. 1, flowering shoot; 2, flower; 3, the same in vertical section; 4, fruit; 5, seed. 2 and 3, enlarged (Wo).

Pyrus Malus, L. Apple. A very bushy and densely branched shrub or tree (see p. 199) up to 20 feet or so in height. Twigs purplish-brown, hairy and more or less angular at the tips. Dwarf-shoots often pointed and almost thorny, standing out at right angles and swollen at the base.

8 8 *Leaf-scars broad and short, nearly elliptical. Leaves not hoary. Flowers not pink and fruit not a pome.*

△ *Buds devoid of scales, hairy; twigs red-brown passing to greyish. Leaves elliptic, thin, smooth, with pinnate curved venation. Flowers small, white, in tufts. Fruits red to black drupes.*

Rhamnus Frangula, L. Alder Buckthorn (Fig. 130). A dark, erect, besom-branched shrub, up to 12 feet or so in height, with numerous nodulose dwarf-shoots. Differs from *R. catharticus* in its alternate leaves, lack of thorns, &c. (see p. 232).

△△ *Buds scaly, smooth or nearly so; twigs olive to brown and slightly angular. Leaves ovate, nearly glabrous and not curved-veined. Flowers rosaceous; fruit a black drupe.*

Prunus domestica, L. Plum. Shrub or bushy small tree up to 30 feet or more in height, passing into *Prunus spinosa* and its variety *insititia*, especially when these are, as sometimes happens, devoid of thorns.

Thornless forms of *Rhamnus catharticus* and of *Crataegus Oxyacantha* will also come here (see pp. 232—3).

†† Loosely or sparsely branched shrubs, with long erect wand-like or switch-like withy twigs, often as suckers.

⊙ *Long shoots with the buds, leaf-scars and leaves in two rows, distichous, truly alternate.* [For (⊙⊙) see p. 261.]

▱ *Branches glistening red-brown to greyish, the periderm peeling in papery films as*

in the Cherry; twigs with glandular hairs. Flowers in catkins; fruit invested by a leafy cupule, nut.

Corylus Avellana, L. Hazel (Fig. 78, see also p. 173). An irregularly branched shrub, or occasionally tree-like, 3—20 feet high; often coppiced, and then with long whippy shoots from the stock. Twigs rather thick, glandular hairy, olive-brown passing to smooth brown-grey peeling branches, with prominent lenticels. The general aspect of the oblique-based leaves recalls those of the Elms (and *Ulmus campestris* is often found growing in hedges with similar habit); but the reddish glandular hairs of the shoots, the very different flowers and fruits, and the periderm, sharply distinguish them, especially as the Elm frequently developes large corky ridges in such situations, and the branches are tawny-grey.

Acer campestre, also often as a bush with the foregoing, is of course quite different (see p. 185).

Other shrubs, owing their habit of coppicing, are the Osier Willows (see pp. 263—8), and closely cut Oaks, Hornbeams, Elms, Chestnut, Alder, and Poplars, the characteristics of which may be sought in the table of trees. It must be borne in mind that many other trees and shrubs, though not all, may occur in coppice form. In addition to the foregoing, and less frequently met with are, Ash, *Robinia*, Lime, Walnut, Beech and Birch, and it may be mentioned that the long coppice-shoots frequently exhibit peculiarities such as larger, or even differently shaped, leaves, longer internodes, larger pith, &c., &c.

▱▱ *Branches not peeling, but corky ridged or fissured; twigs not glandular hairy. Flowers not in catkins. Fruit a winged oval samara.*

Ulmus campestris, L. Elm. For further details see p. 202.

⊙⊙ *Twigs, buds, leaf-scars and leaves not distichous, but more or less evidently spiral in arrangement.*

▱ *Twigs very thick and lax, with large leaf-scars, and a large, very pointed, terminal bud; white latex. Leaves lobed. Flowers small, in a hollow "Fig."*



Fig. 131. *Sarothamnus scoparius*, Broom (Wo).

Ficus Carica, L. Fig. Usually a spreading lax shrub, with long, wand-like, rounded and smooth, olive-green to greyish-brown twigs ascending or spreading. In favourable situations a diffuse short-stemmed tree up to 20 feet or so in height, with widely extended branches and loose foliage.

▱▱ *Twigs neither stout nor milky; leaf-scars and buds small; leaves not lobed; fruit capsular.*

§ *Typical switch-plant, with slender green angular and furrowed twigs; small trifoliate leaves. Flowers yellow papilionaceous; fruit a legume.*

Sarothamnus scoparius, Koch. Broom (Fig. 131). Besom-like shrub, 3—6 feet, with the long, tough, thin, channelled shoots 5-angled and slightly rough, and passing to greenish-grey, smooth but finely fissured branches. Buds minute, subtended by extremely small rounded leaf-scars.

§§ *Twigs not conspicuously angular nor channelled; leaves simple. Flowers not papilionaceous. Fruit capsular; seeds small comose.*

‡ *Shoots very slender, and densely covered with grey-green scale-like leaves, giving the plant a peculiarly plumose aspect. Twigs and branches reddish to purple-brown. Flowers pink in spikes.*

Tamarix gallica, L. Tamarisk. Often a small tree (see p. 197).

‡‡ *Shoots not covered with scaly-leaves, nor plumose. Twigs stiff and erect. Buds with one scale only. Flowers in catkins.*

[For (÷÷) see p. 268.]

÷ *Osiers—i.e. continually cut back to the ground, and sending up new shoots to replace those removed; these grow out in all directions, the general effect being like that of a fountain of long withy twigs. All with narrow, more or less lanceolate leaves, and attaining heights of* 5—10 *feet.*

8 *Buds, leaves and leaf-scars sub-opposite; twigs purplish to olive. Stamen one.*

Salix purpurea, L. Purple Willow (Fig. 132). A basket-osier about 5—10 feet high, characterised by the

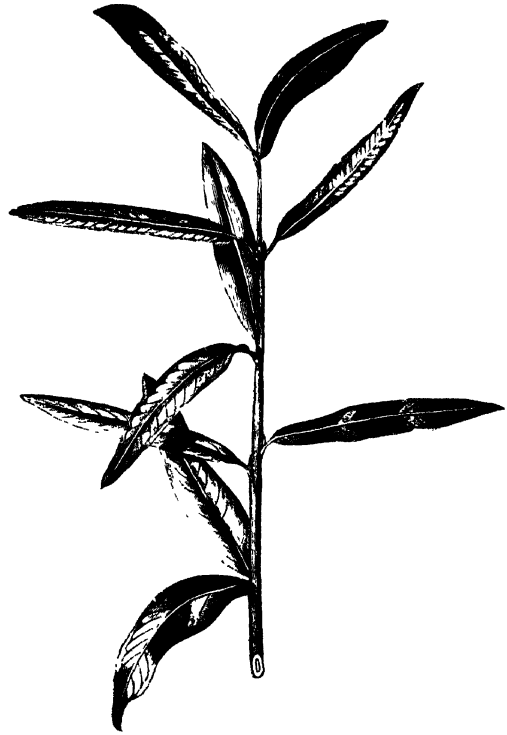


Fig. 132. *Salix purpurea*, Purple Willow (Sc).

sub-opposite leaves and by having only one stamen (of two fused). The twigs are apt to trail, and are typically reddish or purple, but the branches are of various shades

of yellowish-grey, olive, &c. Leaves narrow lanceolate, glabrous. One of its numerous varieties is so generally attacked by a *Cynips*, which causes its leaves to produce pink galls, that it is termed Rose Willow.

8 8 *Leaves alternate, spiral; stamens* 2—5.



Fig. 133. *Salix viminalis*, Osier (Sc).

Δ *Twigs long and thin, bright yellow, silky at the tips, as are the buds; branches orange to yellow-brownish. Capsule glabrous. Stamens* 2.



Fig. 134. *Salix triandra*, Almond Willow (Sc).

Salix vitellina, L. Golden Osier. A variety of *S. alba*, but though it may be a tree 30—50 feet high, it is usually seen in the Osier form up to 8—10 feet in height, the

bright yolk-yellow twigs silky at the tips being the characteristic feature. Leaves lanceolate, whitish, silky-pubescent.

△△ *Twigs not bright yellow, but more or less olive to brown.*



Fig. 135. *Salix alba*, White Willow. 1, male catkin; 2, a male flower; 3, shoot with female catkin; 4, female flower; 5, fruiting catkin; 6, fruit with escaping seeds; 7, seed with its coma. 2, 4, 6 and 7, magnified (Sw).

♂ *Twigs and buds velvety, olive-green to purplish; leaves very narrow, linear, and silky beneath. Capsule downy. Stamens* 2.

Salix viminalis, L. Osier (Fig. 133). Large shrub 10—20 feet high, but best known as our commonest basket-willow. Twigs and branches more or less olive. Leaves very narrow, linear-lanceolate, and very white-silky beneath.

Buds pubescent. Shoots densely velvety passing to smooth dull yellowish.

Shoots and buds smooth, more or less brown; leaves lanceolate glabrous. Capsule glabrous. Stamens 3.

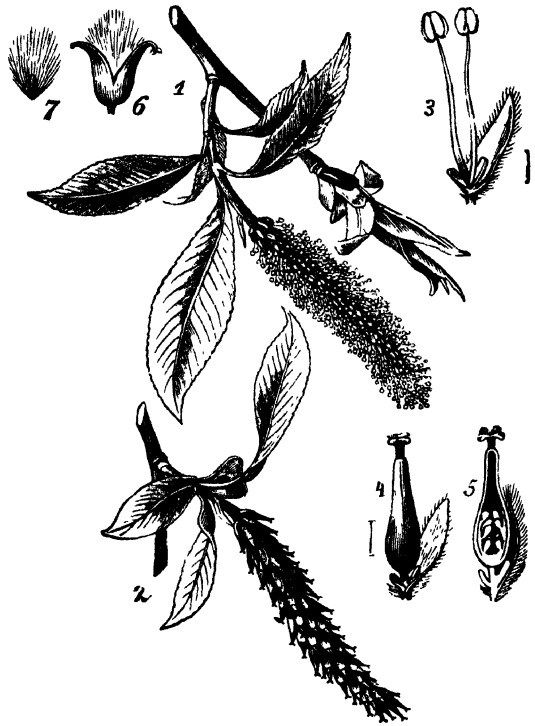


Fig. 136. *Salix fragilis*, Crack Willow. 1, male, and 2, female flowering shoot; 3, male, and 4, female flower, enlarged; 5, vertical section of latter; 6, ripe capsule; 7, seed (Wo).

Salix triandra, L. Almond Willow (Fig. 134). A tree up to 20 feet high, but oftener seen as an Osier. Leaves

narrow, lanceolate, glabrous, glaucous beneath. Twigs olive-brown or reddish, smooth, bearing brown buds. Characterised by its 3 stamens. Remarkable in casting the bark in grey scales, or flakes.

÷÷ *Shrubs or small bushy trees, not true Osiers.*

8 *Shoots and young leaves silky pubescent; older leaves silky beneath; twigs not fragile at the insertion.*

Salix alba, L. White Willow (Fig. 135). A round-headed tree 50—80 feet, often pollarded, and certain varieties—e.g. *vitellina*—planted as Osiers. Bark yellowish-grey, deeply fissured; twigs smooth, yellowish to olive-brown, not brittle at the insertions. The shoots and lower surfaces of the lanceolate leaves are whitish with appressed silky pubescence. *S. fragilis* is devoid of this silky covering and its twigs are brittle at the insertion.

8 8 *Leaves not silky, and twigs fragile.*

Salix fragilis, L. Crack Willow (Fig. 136). A tree up to 50—60 feet in height or more, usually more bushy-headed than *S. alba*, owing to closer and more crossing branches, but especially characterised by the fragility of the twigs at their insertions. Twigs smooth, polished, yellowish-grey to pale brown or olive. Leaves narrow, lanceolate, not silky beneath. Old bark fissured, thick. The so-called Huntingdon Willow, *S. Russelliana*, is possibly a hybrid between this and *S. alba*, or a variety allied to them. They all occur as Pollard Willows.

APPENDIX.

SEEDLINGS.

CLASSIFICATION OF TREES AND SHRUBS ACCORDING TO THEIR SEEDLINGS

I. EMBRYO AND SEEDLING WITH 5—10 (RARELY MORE OR FEWER) COTYLEDONS; THE LATTER NARROW ACICULAR, LINEAR OR SUBULATE. GERMINATION EPIGEAL. POLYCOTYLEDONOUS CONIFERÆ.

[For (II) see p. 275.]

A. COTYLEDONS ENTIRE.

[For (B) see p. 274.]

(1) **Primary leaves also entire.**

[For (2) see p. 272.]

(a) **Primary leaves equal in number to the cotyledons and alternating with them.**

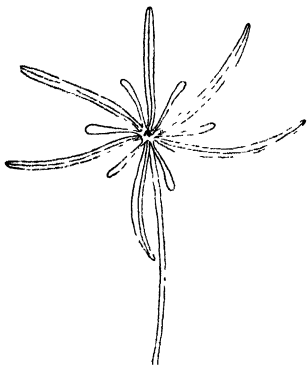


Fig. 187. *Abies pectinata*, Silver Fir, $\frac{1}{16}$ (E.D.).

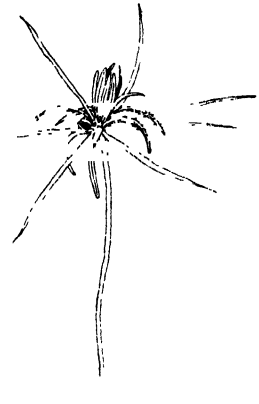


Fig. 138. *Larix europæa*, Larch, $\frac{1}{8}$ (E.D.).

Abies pectinata, L. Silver Fir (Fig. 137).

(b) **Primary leaves not regularly alternating.**

(i) Epicotyl glabrous.

Larix europœa, L. Larch (Fig. 138).

(ii) Epicotyl pubescent.

(*a*) *Cotyledons* 8—10, 30—35 *mm. long.*

Cedrus atlantica. Atlas Cedar (compare Fig. 139).

(*β*) *Cotyledons* 5—7, 15—20 *mm. long.*

Pseudotsuga Douglasii. Douglas Fir.

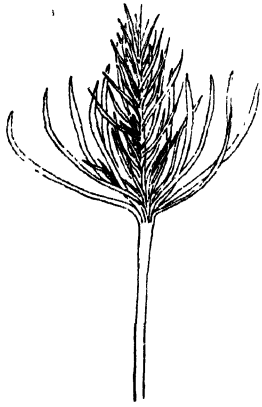


Fig. 139. *Cedrus Libani*, Cedar of Lebanon (E.D.).

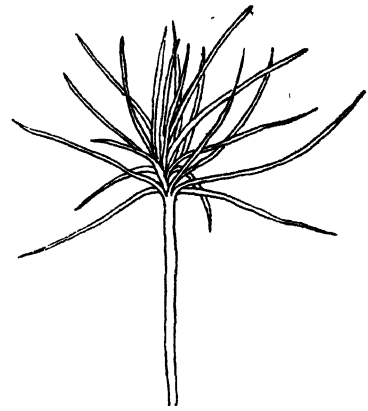


Fig. 140. *Pinus sylvestris*, Scots Pine, slightly magnified (E.D.).

(2) Primary leaves serratulate followed by 2-leafed shoots in the second year.

(a) Cotyledons less than 20 mm. long, about 5—7 in number.

Pinus sylvestris, L. Scots Pine (Fig. 140).

In most respects the seedling of *P. montana* resembles that of *P. sylvestris.*

(b) Cotyledons 30 or more mm. in length, and about 6—10 in number.

Pinus Laricio (Fig. 141).

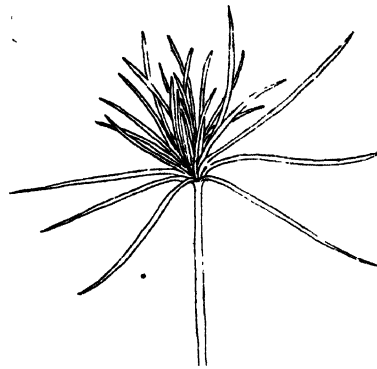


Fig. 141. *Pinus Laricio*, Austrian Pine, $\frac{1}{7}$ (E.D.).

Pinus Pinaster (Figs. 142, 143) also comes with *P. Laricio*.



Fig. 142. *Pinus Pinaster*, Cluster Pine, $\frac{1}{5}$ (E.D.).

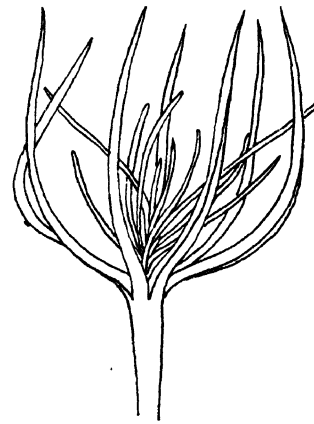


Fig. 143. *Pinus Pinaster*, Cluster Pine, $\frac{1}{5}$ (E.D.).

B. COTYLEDONS AS WELL AS PRIMARY LEAVES SERRATULATE OR HAIRY.

(1) All leaves single and isolated; cotyledons and primary leaves tough.

Picea excelsa, L. Spruce (Fig. 144).

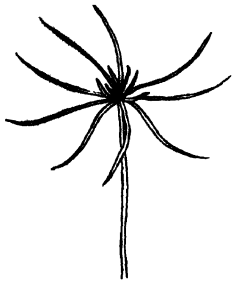


Fig. 144. *Picea excelsa*, Spruce, $\frac{5}{6}$ (E.D.).



Fig. 145. *Pinus Pinea*, Stone Pine (E.D.).

(2) Primary single leaves succeeded in the second year by 2- to 5-leaved shoots.

(a) Second year shoots bearing 2-leafed tufts; seedling and cotyledons very tough.

Pinus Pinea. Stone Pine (Fig. 145).

(b) Second year shoots bearing 5-leaved tufts.

(i) Seedling and cotyledons tough.

Pinus Cembra. Arolla Pine (Fig. 146).

(ii) Seedling and cotyledons very slender.

Pinus Strobus. Weymouth Pine (Fig. 147).

With *P. Strobus* comes *P. excelsa.*

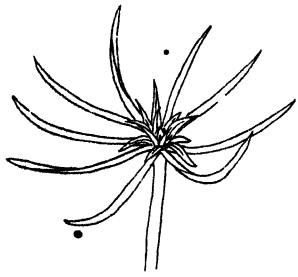


Fig. 146. *Pinus Cembra*, Arolla Pine, $\frac{1}{4}$ (E.D.).

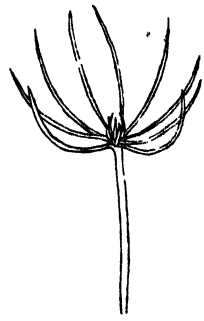


Fig. 147. *Pinus Strobus*, Weymouth Pine, $\frac{2}{5}$ (E.D.).

II. EMBRYO AND SEEDLING WITH 2 COTYLEDONS ONLY.

(Abnormal specimens of *Acer*, *Berberis*, &c. may have 3.)

A. GERMINATION EPIGEAL.

[For (B) see p. 293.]

(1) Cotyledons elongated and very narrow, linear, &c. Gymnosperms.

[For (2) see p. 276.]

(a) Primary leaves spirally inserted.

Taxus baccata. Yew (Figs. 148, 149).

(b) Primary leaves opposite or in whorls of 4.

(i) Cotyledons 15—16 mm. long.

(*α*) *Plumule developing into a 4-angular shoot with scaly leaves.*

Cupressus sempervirens. Roman Cypress (Fig. 150).

(*β*) *Plumule developing into a shoot bearing subulate leaves in whorls.*

Juniperus communis. Juniper (Fig. 151).

(ii) Cotyledons 5—10 mm. long: plumule developing into a flattened shoot with scaly leaves.

Thuja. Arbor Vitæ (Fig. 152).

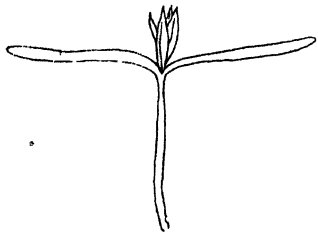


Fig. 148. *Taxus baccata*, Yew, slightly magnified (E.D.).

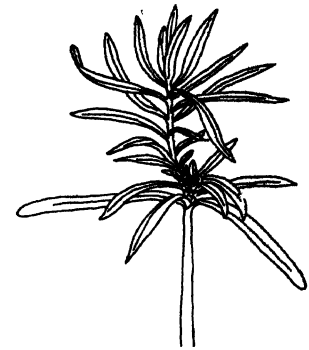


Fig. 149. *Taxus baccata*, Yew, slightly magnified (E.D.).

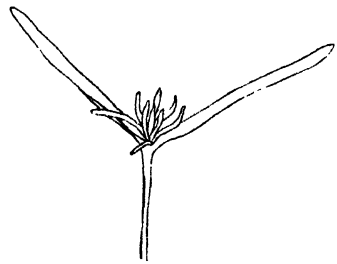


Fig. 150. *Cupressus sempervirens*, Roman Cypress, ⅘ (E.D.).

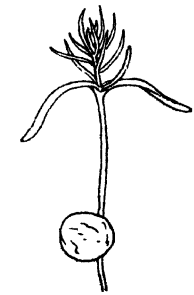


Fig. 151. *Juniperus communis*, Juniper, ⅘ (E.D.).

(2) Cotyledons not very narrow (linear, acicular, &c.) but with an appreciable breadth of surface—i.e. more than ¼ length.

(a) **Cotyledons thick and fleshy, plano-convex.**

(i) First leaf trifid, hairy.

Cratægus Oxyacantha. Hawthorn (Fig. 153).

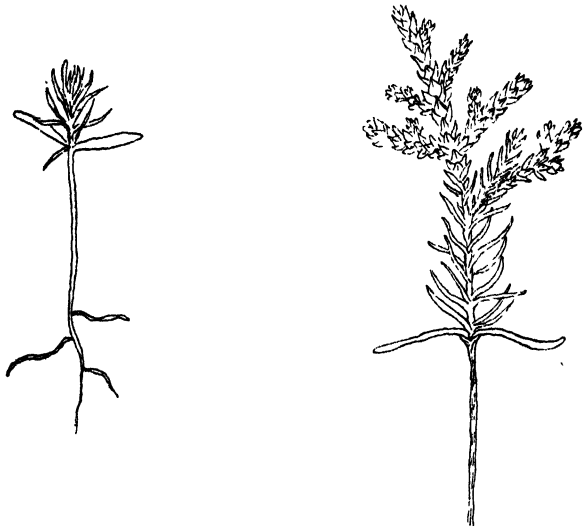


Fig. 152. *Thuja occidentalis*, Arbor Vitæ (E.D.).

(ii) First leaf not lobed; simple and serratulate.

Prunus Padus, Bird Cherry (Fig. 154). ***Prunus Mahaleb*** (Fig. 155). *Prunus spinosa*, Blackthorn (Fig. 156). *Prunus insititia*, Bullace. *Prunus domestica*, Plum (Fig. 157). *Pyrus Aria*, White Beam (Fig. 158) and other species. [See also Addendum p. 299.]

(b) **Cotyledons herbaceous and flat.**

(i) Cotyledons cut into lobes, and not longer than broad. [For (ii) see p. 280.]

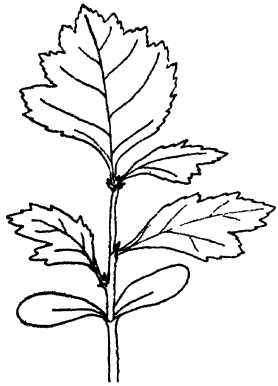


Fig. 153. *Cratægus Oxyacantha*, Hawthorn (E.D.).

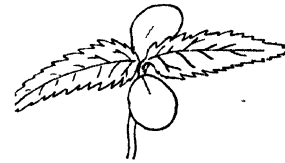


Fig. 154. *Prunus Padus*, Bird Cherry, ½ (E.D.).

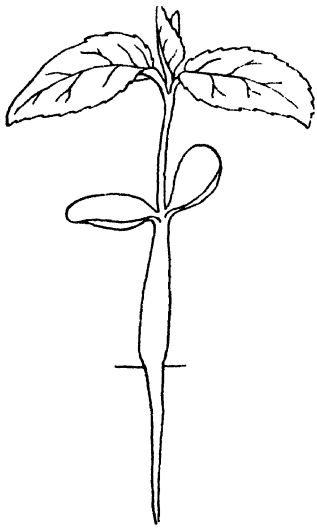


Fig. 155. *Prunus Mahaleb*, ½ (E.D.).



Fig. 156. *Prunus spinosa*, Blackthorn, ½ (E.D.).

(*a*) *Cotyledons palmatifid, 5-lobed and pubescent.*

Tilia europœa. Lime (Figs. 98, 159).

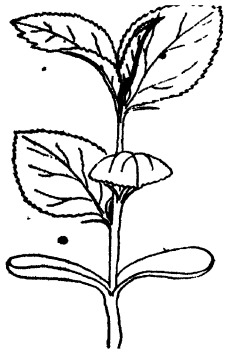


Fig. 157. *Prunus domestica*, Plum, ¼ (E.D.).

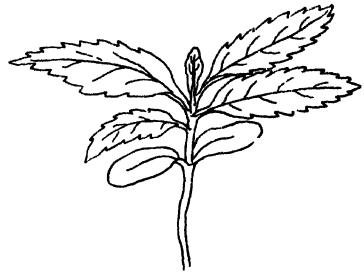


Fig. 158. *Pyrus Aria*, White Beam, ¼ (E.D.).

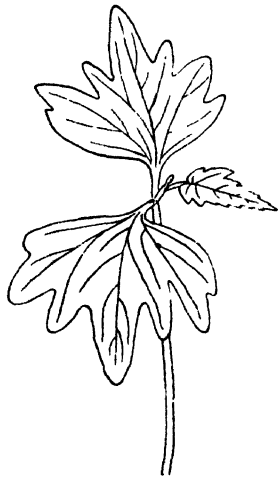


Fig. 159. *Tilia europœa*, Lime, ¼ (E.D.).

(β) *Cotyledons slightly 2-lobed at the apex.*

Rhamnus catharticus. Buckthorn (Fig. 160).

(ii) Cotyledons not lobed: entire.



Fig. 160. *Rhamnus catharticus*, Buckthorn (E.D.).

[For (β) see p. 283.]

(a) *Cotyledons long and narrow, linear-oblong or lanceolate, at least 3—4 times as long as broad.*

[For (**) see p. 282.]

* Primary leaves opposite, simple.

[For (††) see p. 281.]

† Primary leaves more or less cordate; cotyledons with 3 parallel nerves.

⊙ *Petiole and margins of primary leaves ciliate.*

Acer campestre. Maple (Figs. 161, 162).

⊙⊙ *Petioles and leaves quite glabrous.*

▱ *Cotyledons with transverse cracks.*

Acer platanoides. Norway Maple (Fig. 109).

▱▱ *Cotyledons devoid of transverse cracks.*

Acer Pseudo-Platanus. Sycamore (Figs. 110, 163, 164).

†† Primary leaves not cordate.

⊙ *Primary leaves lobed at the margins.*

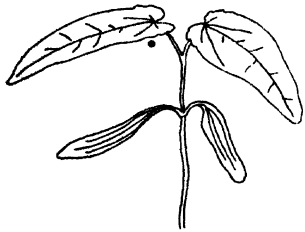


Fig. 161. *Acer campestre,* Maple, reduced (E.D.).

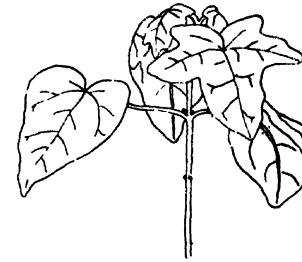


Fig. 162. *Acer campestre,* Maple, reduced (E.D.).

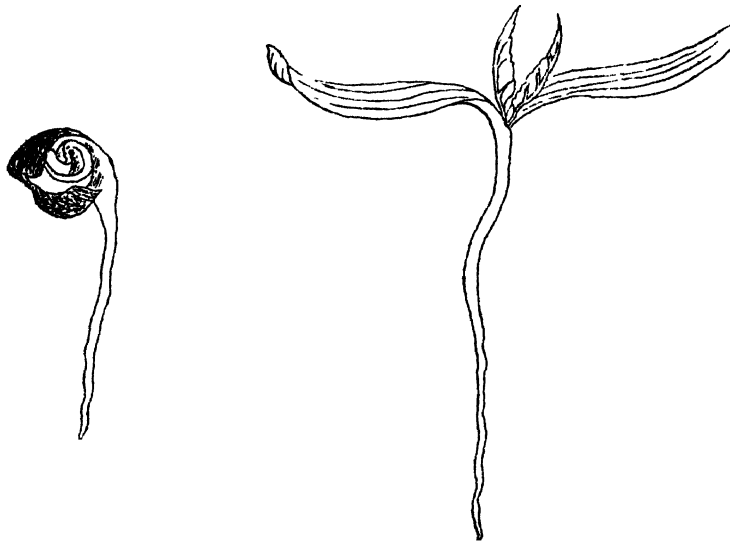


Fig. 163. *Acer Pseudo-Platanus,* Sycamore, $\frac{8}{10}$ (E.D.).

Viburnum Opulus. Guelder Rose.

[Also *Fraxinus excelsior* comes here when its primary leaves are lobed, see Figs. 167—70.]

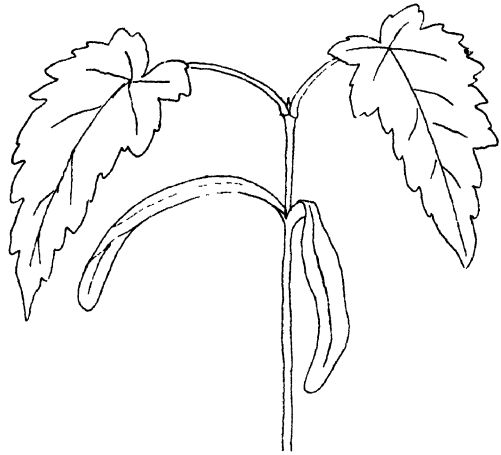


Fig. 164. *Acer Pseudo-Platanus*, Sycamore, $\frac{2}{10}$ (E.D.).

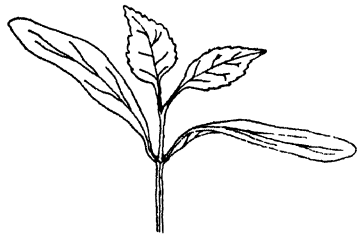


Fig. 165. *Fraxinus excelsior*, Ash (E.D.).



Fig. 166. *Fraxinus excelsior*, Primary leaf, $\frac{1}{2}$ (E.D.).

⊙⊙ *Primary leaves not lobed, ovate serrate.*

Fraxinus excelsior. Ash (Figs. 90, 165—70).

** Primary leaves alternate.

† Primary leaves glandular pubescent, and slightly dentate at apex.



Fig. 167. *Fraxinus excelsior*, Primary leaf, ⅔ (E.D.).

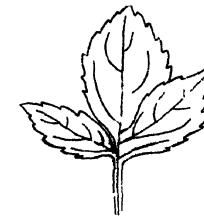


Fig. 168. *Fraxinus excelsior*, Primary leaf, ⅔ (E.D.).



Fig. 169. *Fraxinus excelsior*, ⅔ (E.D.).

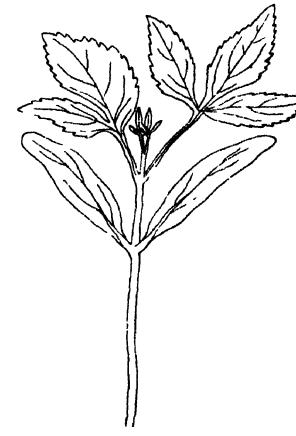


Fig. 170. *Fraxinus excelsior*, ⅔ (E.D.).

Platanus. Plane.

Berberis Aquifolium also comes here.

†† Primary leaves glabrous and spinose-serrate.

Berberis vulgaris. Barberry (Fig. 172).

(β) *Cotyledons short and broad, the length not more than twice the breadth.*

[For (**) see p. 286.]

[For (††) see p. 285.]

Primary leaves, or at least the second or third one, compound.

† Primary leaves and shoot distinctly hairy.

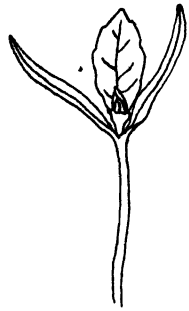


Fig. 171. *Platanus*, Plane (E.D.).



Fig. 172. *Berberis vulgaris*, Barberry, ½ (E.D.).



Fig. 173. *Ulex europæus*, Gorse (E.D.).

⊙ *Primary leaves gradually passing into spines.*

Ulex europœus. Gorse (Fig. 173).

⊙⊙ *Primary leaves never becoming spines.*

▱ *Cotyledons* 14—18 *mm.* × 8—10 *mm.; primary leaf very regularly trifoliate, silky.*

Cytisus Laburnum. Laburnum.

▱▱ *Cotyledons* 5—10 *mm.* × 3—4 *mm.; primary leaf very irregularly trifoliate and glandular.*

Rhus typhina. Sumach (Fig. 174).

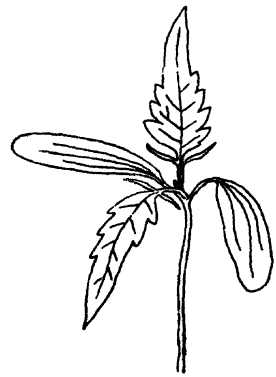


Fig. 174. *Rhus typhina*, Sumach (E.D.).

++ Primary leaves glabrous or nearly so.

⊙ *Primary leaves sub-opposite; each having one large and two small acute or acuminate leaflets.*

Ailanthus glandulosa. Tree of Heaven (Fig. 175).

⊙⊙ *First leaf sub-rotund, simple; the second having three obtuse leaflets.*

Robinia Pseud-acacia. False Acacia.

** Primary leaves all simple.

[For (††) see p. 287.]

† Primary leaves more or less cut into lobes.

⊙ *Primary leaves glabrous or nearly so.*

▱ *First leaf tripartite and serrate.*

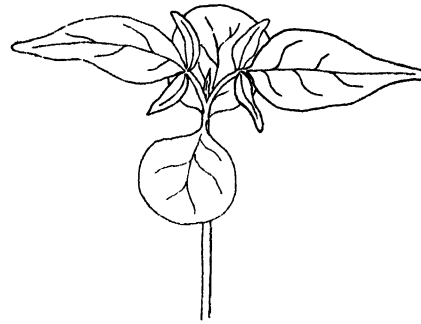


Fig. 175. *Ailanthus glandulosa*, Tree of Heaven, ¼ (E.D.).

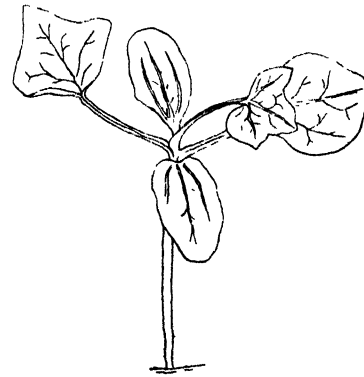


Fig. 176. *Hedera Helix*, Ivy (E.D.).

Pyrus Aucuparia. Rowan.

▱▱ *First leaf a mere rudiment; the second angular, hardly trifid.*

Hedera Helix. Ivy (Fig. 176).

⊙⊙ *Primary leaves and shoot distinctly hairy.*

▱ *Primary leaves glandular hairy and seedling fragrant or strong-smelling when bruised; cotyledons thin.*

§ *Cotyledons not more than* 3—4 *mm. long.*

Betula alba. Birch (Fig. 177).

§§ *Cotyledons* 9—10 *mm. long.*

Ribes nigrum. Black Currant (Fig. 178).

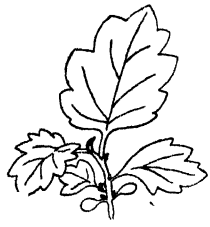


Fig. 177. *Betula alba*, Birch (E.D.).

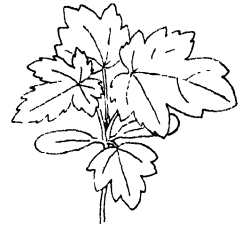


Fig. 178. *Ribes nigrum*, Black Currant, ¾ (E.D.).

▱▱ *Primary leaves pubescent, with no special odour; cotyledons sub-coriaceous.*

Cratægus Oxyacantha. Hawthorn (Fig. 153).

†† Primary leaves entire or toothed but not cut into lobes.

⊙ *Primary leaves entire, or merely sinuous.* [For (⊙⊙) see p. 289.]

▱ *Primary leaves opposite.* [For (▱▱) see p 89.]

§ *Cotyledons large, about* 15—30 × 25—45 *mm., broader than long.*

Fagus sylvatica. Beech (Figs. 179, 180).

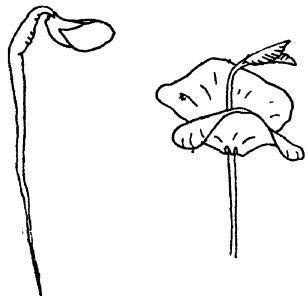


Fig. 179. *Fagus sylvatica*, Beech, ⅔ (E.D.).

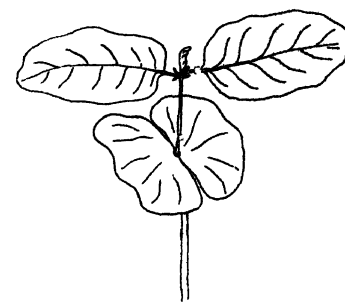


Fig. 180. *Fagus sylvatica*, Beech, ⅔ (E.D.).

§§ *Cotyledons longer than broad, small, under* 15 *mm.*

‡ *Primary leaves and shoot with silvery-bronze lustre.*

Hippophaë rhamnoides. Sea Buckthorn (Fig. 181).



Fig. 181. *Hippophaë rhamnoides*, Sea Buckthorn, ½ (E.D.).

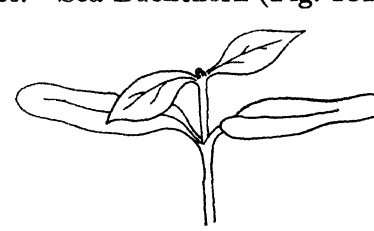


Fig. 182. *Syringa vulgaris*, Lilac, ⅔ (E.D.).

‡‡ *Primary leaves and shoot devoid of scaly silver-bronze lustre, glabrous or nearly so.*

÷ *Primary leaves dull green, herbaceous, acute.*

Syringa vulgaris. Lilac (Fig. 182).

÷ ÷ *Primary leaves shining green, hard, obtuse.*

Buxus sempervirens. Box (Fig. 183).

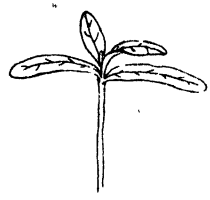


Fig. 183. *Buxus sempervirens*, Box (E.D).

▱▱ *Primary leaves alternate; cotyledons and seedling minute.*

§ *Primary leaf glabrous.*

Salix repens. Creeping Willow (Fig. 184).



Fig. 184. *Salix repens*, Creeping Willow, ½ (E.D.).



Fig. 185. *Salix phylicifolia*, Tea-leafed Willow, ½ (E.D.).



Fig. 186. *Salix nigricans*, Black Willow, ½ (E.D.).

§§ *Primary leaf pubescent.*

Salix cinerea.

Other species of *Salix* (Figs. 185, 186) and *Populus* also come here.

⊙⊙ *Primary leaves toothed or serrate.*

▱ *Primary leaves opposite or sub-opposite*.* [For (▱▱) see p. 291.]

§ *Primary leaves glabrous.*

‡ *Primary leaves spinescent-toothed.*

Ilex Aquifolium. Holly (Fig. 187).

‡‡ *Primary leaves not spinescent, but serrate; cotyledons over 20 mm. long.*

* [See also Addendum, p. 299.]

÷ *Cotyledons with* 3—5 *principal veins.*

Aucuba japonica (Fig. 188).

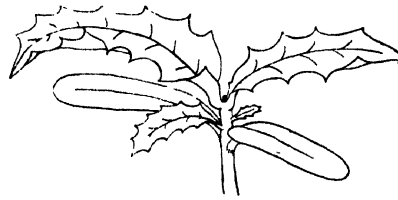


Fig. 187. *Ilex Aquifolium*, Holly (E.D.).

÷÷ *Cotyledons with but one principal vein.*

Euonymus europæus. Spindle Tree (Fig. 189).

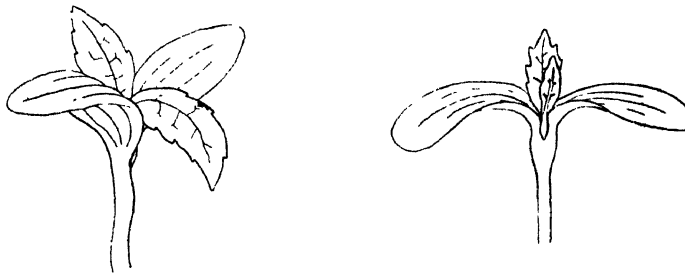


Fig. 188. *Aucuba japonica*, Aucuba (E.D.).

§§ *Primary leaves pubescent; cotyledons* 8—15 *mm. long.*

‡ *Primary leaves cordate.*

Sambucus nigra. Elder (Fig. 190).

‡‡ *Primary leaves not cordate.*

Morus, Mulberry (Fig. 191). *Cornus*, Dogwood. *Sym-*

phoricarpos racemosus, Snowberry (Fig. 192). *Lonicera* (Figs. 193, 194).



Fig. 189. *Euonymus europæus*, Spindle-tree, $\frac{1}{8}$ (E.D.).



Fig. 190. *Sambucus nigra*, Elder (E.D.).

▱▱ *Primary leaves alternate.*

§ *Primary leaves glabrous.*

‡ *Roots with nodosities.*

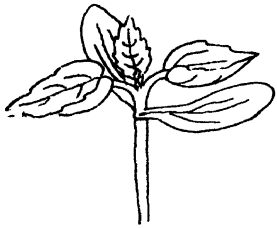


Fig. 191. *Morus nigra*, Black Mulberry, $\frac{3}{4}$ (E.D.).



Fig. 192. *Symphoricarpos racemosus*, Snowberry, $\frac{3}{5}$ (E.D.).

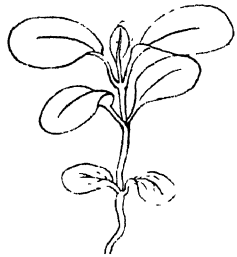


Fig. 193. *Lonicera Periclymenum*, Honeysuckle, $\frac{3}{4}$ (E.D.).

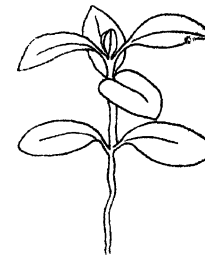


Fig. 194. *Lonicera Xylosteum*, Fly Honeysuckle, $\frac{3}{4}$ (E.D.).

Alnus glutinosa. Alder (Fig. 195).

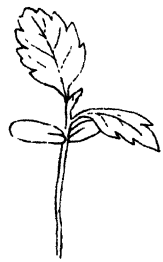


Fig. 195. *Alnus glutinosa*, Alder, $\frac{3}{4}$ (E.D.).

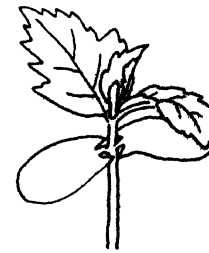


Fig. 196. *Carpinus Betulus*, Hornbeam, $\frac{3}{4}$ (E.D.).

‡‡ *Roots devoid of nodosities*

Carpinus Betulus, Hornbeam (Fig. 196). *Pyrus communis*, Pear (Fig. 197).

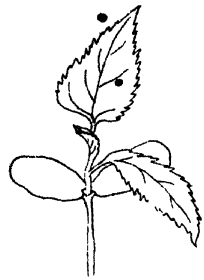


Fig. 197. *Pyrus communis*, Pear (E.D.).



Fig. 198. *Rhododendron ponticum*, Rhododendron, ¼ (E.D.).

§§ *Primary leaves hairy.*

Rhododendron (Fig. 198). *Pyrus Malus*, Apple (Fig. 199). Some species of *Prunus* (compare pp. 277—9).

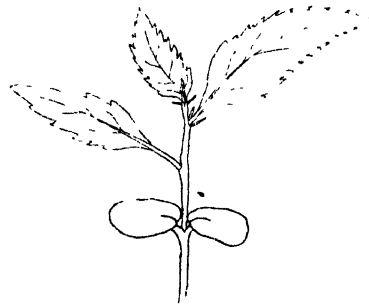


Fig. 199. *Pyrus Malus*, Apple (E.D.).

B. GERMINATION HYPOGEAL; COTYLEDONS THICK AND FLESHY.

(1) Cotyledons large and corrugated, brain-like; primary leaves scale-like; seedling aromatic.

Juglans regia. Walnut (Fig. 200).

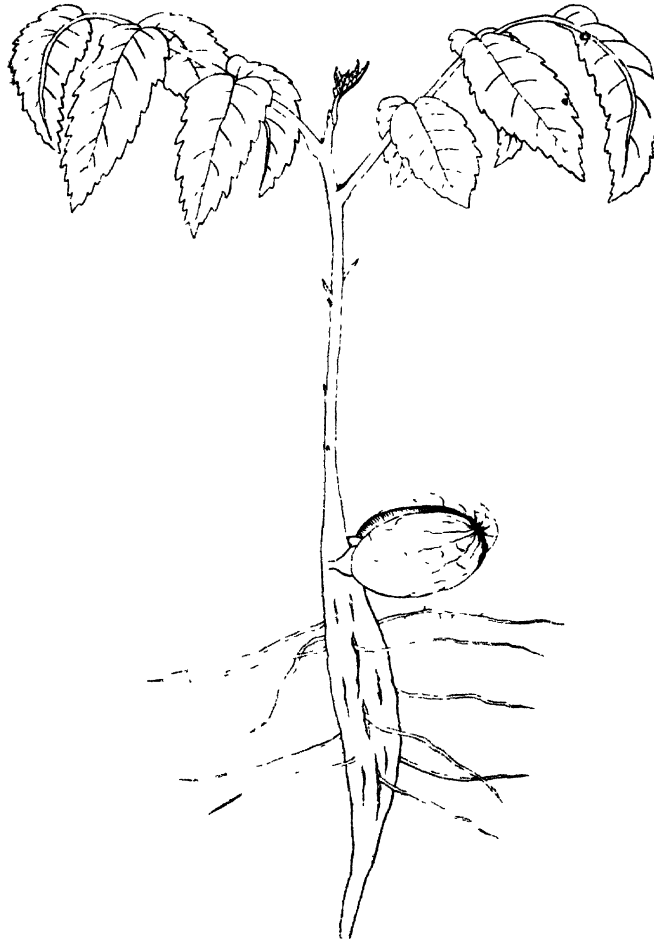


Fig. 200. *Juglans regia*, Walnut, ¼ (E.D.).

(2) Cotyledons plano-convex, large.

(a) Primary leaves opposite and compound.

Æsculus Hippocastanum. Horse-chestnut (Fig. 201).



Fig. 201. *Æsculus Hippocastanum*, Horse-Chestnut, ¼ (E.D.).

(b) Primary leaves alternate and not compound.

(i) Primary leaves scale-like.

Quercus. Oak (Figs. 202—5).

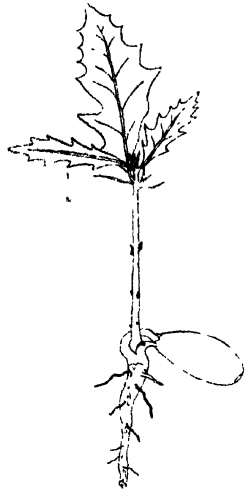


Fig. 202. *Quercus Cerris*, Turkey Oak (E.D.).

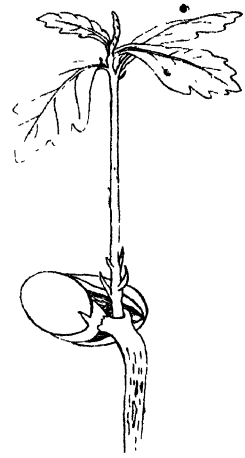


Fig. 203. *Quercus Robur* var. *sessiliflora*, Sessile Oak, $\frac{4}{1}$ (E.D.).

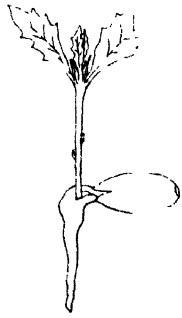


Fig. 204. *Quercus Ilex*, **Holme Oak (E.D.).**

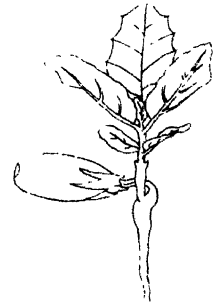


Fig. 205. *Quercus Suber*, **Cork Oak, $\frac{1}{3}$ (E.D.).**

(ii) Primary leaves foliaceous: cotyledons starchy.

(*a*) *First leaf entire.*

Castanea vesca. Chestnut (Fig. 206).

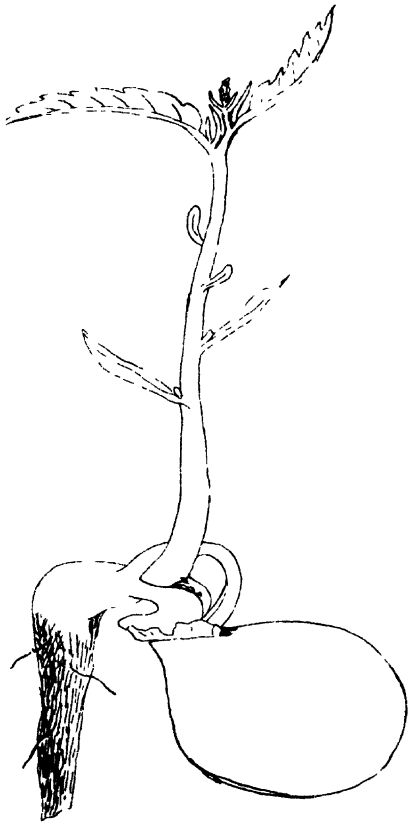


Fig. 206. *Castanea vesca*, Chestnut, reduced slightly (E.D.).

(β) *First leaf serrate: cotyledons oily.*

Corylus Avellana, Hazel (Fig. 207). *Prunus Amygdalus*, Almond (Fig. 208). *Rhamnus Frangula*, Alder Buckthorn (Fig. 209).

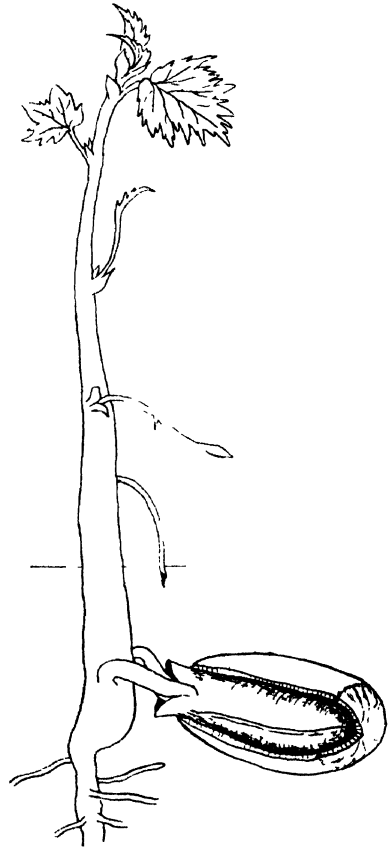


Fig. 207. *Corylus Avellana*, Hazel (E.D.).

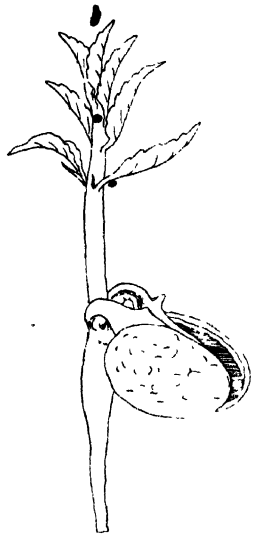


Fig. 208. *Prunus Amygdalus*, Almond, $\frac{1}{2}$ (E.D.).



Fig. 209. *Rhamnus Frangula*, Alder Buckthorn, $\frac{2}{3}$ (E.D.).

ADDENDUM

[The Analytical Table does not include reference to seedlings of the Elms, *Ulmus montana* and *U. campestris*, whose shortly-stalked, epigeal, somewhat fleshy cotyledons are slightly longer than broad and are characterised by the pair of teeth into which the base of each lamina is prolonged. The first two primary leaves are opposite, and ovate with serrate margins. Seedlings of *U. campestris* are excessively rare in this country.]

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